TENNESSEE DEPARTMENT
OF
ENVIRONMENT AND CONSERVATION

DOE OVERSIGHT DIVISION

ENVIRONMENTAL MONITORING REPORT

JANUARY THROUGH DECEMBER 2004

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LIST OF COMMON ACRONYMS AND ABBREVIATIONS

ASER	Annual Site Environmental Report (written by DOE)
ASTM	American Society for Testing and Materials
BCK	Bear Creek Kilometer (station location)
BFK	Brushy Fork Creek Kilometer (station location)
BJC	Bechtel Jacobs Company
BMAP	Biological Monitoring and Abatement Program
BNFL	British Nuclear Fuels Limited
BOD	Biological Oxygen Demand
BWXT	Y-12 Prime Contractor (current)
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CAP	Citizens Advisory Panel (of LOC)
CCR	Consumer Confidence Report
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
COC	Contaminants of Concern
COD	Chemical Oxygen Demand
CPM (cpm)	Counts per Minute
CRM	Clinch River Mile
CROET	Community Reuse Organization of East Tennessee
CWA	Clean Water Act
CYRTF	Coal Yard Runoff Treatment Facility (at ORNL)
D&D	Decontamination and Decommissioning
DOE	Department of Energy
DOE-O	Department of Energy-Oversight Division (TDEC)
DWS	Division of Water Supply (TDEC)
E. coli	Escherichia coli
EAC	Environmental Assistance Center (TDEC-Environmental Field Office)
ED1, ED2, ED3	Economic Development Parcel 1, Parcel 2, and Parcel 3
EFPC	East Fork Poplar Creek
EMC	Environmental Monitoring and Compliance (DOE-O Program)
EMWMF	Environmental Management Waste Management Facility
EPA	Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, Trichoptera (May flies, Stone flies, Caddis flies)
ERAMS	Environmental Radiation Ambient Monitoring System
ET&I	Equipment Test and Inspection
ETTP	East Tennessee Technology Park
FDA	U.S. Food and Drug Administration
FFA	Federal Facility Agreement
FRMAC	Federal Radiation Monitoring and Assessment Center
g	Gram
GHK	Gum Hollow Branch Kilometer (station location)
GIS	Geographic Information Systems
GPS	Global Positioning System
GW	Ground Water
GWQC	Ground Water Quality Criteria
HAP	Hazardous Air Pollutant
HCK	Hinds Creek Kilometer (station location)
IBI	Index of Biotic Integrity
IC	In Compliance
"ISCO" Sampler	Automatic Water Sampler
IWQP	Integrated Water Quality Program
K-####	Facility at K-25 (ETTP)

LIST OF COMMON ACRONYMS AND ABBREVIATIONS (CONT'D)

K-25	Oak Ridge Gaseous Diffusion Plant (now called ETTP)
KBL	Knoxville Branch Laboratory
KEAC	Knoxville Environmental Assistance Center
l	Liter
LC_{50}	Lethal Concentration at which 50 % of Test Organisms Die
LMES	Lockheed Martin Energy Systems (past DOE Contractor)
LOC	Local Oversight Committee
LWBR	Lower Watts Bar Reservoir
MARSSIM	Multi-agency Radiation Survey and Site Investigation Manual
MBK	Mill Branch Kilometer (station location)
MCL	Maximum Contaminant Level (for drinking water)
MDC	Minimum Detectable Concentration
MEK	Melton Branch Kilometer (station location)
µg	Microgram
mg	Milligram
MIK	Mitchell Branch Kilometer (station location)
ml	Milliliter
MMES	Martin Marietta Energy Systems (past DOE Contractor)
µmho	Micro mho (mho=1/ohm)
MOU	Memorandum of Understanding
µR	Microroentgen
mrem	1/1000 of a rem – millirem
N, S, E, W	North, South, East, West
NAAQS	National Ambient Air Quality Standards
NAREL	National Air and Radiation Environmental Laboratory
NAT	No Acute Toxicity
NEPA	National Environmental Policy Act
NIC	Not In Compliance
NOAEC	No Observable Adverse Effect Concentration (to Tested Organisms)
NOV	Notice of Violation
NPDES	National Pollution Discharge Elimination System
NRWTF	Non-Radiological Waste Treatment Facility (at ORNL)
NT	Northern Tributary of Bear Creek in Bear Creek Valley
OMI	Operations Management International (runs utilities at ETTP under CROET)
OREIS	Oak Ridge Environmental Information System http://www-oreis.bechteljacobs.org/oreis/help/oreishome.html
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OSHA	Occupational Safety and Health Association
OSL	Optically Stimulated Luminescent (Dosimeter)
OU	Operable Unit
PACE	Paper, Allied-Industrial, Chemical, and Energy Workers Union
PAM	Perimeter Air Monitor
PCB	Polychlorinated Biphenol
pCi	$1x10^{-12}$ Curie (Picocurie)
PCM	Poplar Creek Mile (station location)
pH	Proportion of Hydrogen Ions (acid vs. base)
PWSID	Potable Water Identification "number"
ppb	Parts per Billion

LIST OF COMMON ACRONYMS AND ABBREVIATIONS (CONT'D)

ppm	Parts per Million
ppt	Parts per Trillion
PRG	Preliminary Remediation Goals
QA	Quality Assurance
QC	Quality Control
R	Roentgen
RBP	Rapid Bioassessment Program
RCRA	Resource Conservation and Recovery Act
REM (rem)	Roentgen Equivalent Man (unit)
RER	Remediation Effectiveness Report
ROD	Record of Decision
RSE	Remedial Site Evaluation
SLF	Sanitary Landfill
SNS	Spallation Neutron Source
SOP	Standard Operating Procedure
SPOT	Sample Planning and Oversight Team (TDEC)
SS	Surface Spring
STP	Sewage Treatment Plant
SW	Surface Water
TDEC	Tennessee Department of Environment and Conservation
TDS	Total Dissolved Solids
TIE	Toxicity Identification Evaluation
TLD	Thermoluminescent Dosimeter
TOA	Tennessee Oversight Agreement
TRE	Toxicity Reduction Evaluation
TRM	Tennessee River Mile
TRU	Transuranic
TSCA	Toxic Substance Control Act
TSCAI	Toxic Substance Control Act Incinerator
TSS	Total Suspended Solids
TTHM's	Total Trihalomethanes
TVA	Tennessee Valley Authority
TWQC	Tennessee Water Quality Criteria
TWRA	Tennessee Wildlife Resources Agency
U.S.	United States
UT-Battelle	University of Tennessee-Battelle (ORNL Prime Contractor)
VOAs	Volatile Organic Analytes
VOC	Volatile Organic Compound
WCK	White Oak Creek Kilometer (station location)
WM	Waste Management
WOL	White Oak Lake
X-####	Facility at X-10 (ORNL)
X-10	Oak Ridge National Laboratory
Y-####	Facility at Y-12
Y-12	Y-12 Plant (Area Office)

Executive Summary

The Tennessee Department of Environment and Conservation, DOE Oversight Division (the division) is providing a report of its independent environmental monitoring for the calendar year 2004. The report is a series of individual reports completed by division personnel. General areas of interest organize the reports: Air Quality, Biological/Fish and Wildlife, Drinking Water, Groundwater, Radiation, Surface Water, and Sediment. An abstract is provided in each report. All supporting information and data used in the completion of these reports are available for review in the division's files.

Air Quality Monitoring

Environmental Radiation Ambient Monitoring System (ERAMS) This EPA sponsored program detected elevated radionuclides in air at Y-12. This perimeter program also measured increased airborne radionuclides around the Y-12 plant. These releases are presumably from production and waste management operations. Y-12 has restarted production operations and also is aggressively demolishing unneeded buildings. Air sampling for radionuclides at ORNL mirrored results of background stations. All radiological air-sampling measurements were below Clean Air Act standards.

Perimeter Ambient Air Monitoring The perimeter air-monitoring program on the Oak Ridge Reservation uses low volume air samplers. This program, in conjunction with associated air monitoring programs, provides information used to assess the impact of Department of Energy activities on the local environment and public health. In the program, samples are collected biweekly from twelve air monitors stationed near the boundaries of the reservation and at a background location (i.e., Fort Loudoun Dam). Each sample is analyzed for gross alpha and gross beta radiation at the state radiochemistry laboratory. A composite sample from each location is analyzed annually for gamma emitters. Results from the perimeter monitoring stations are compared to the background measurements and environmental standards provided in the Clean Air Act. The data for 2004 did not indicate a significant impact on local air quality from activities on the reservation.

Fugitive Radiological Air Monitoring High volume air samplers are used to monitor radioactive contaminants at locations where there is a potential for the release of fugitive/diffuse air emissions released on the Oak Ridge Reservation from remedial or waste management activities. During 2004, one of the monitors was stationed between the K-31 and K-33 Process Buildings at the East Tennessee Technology Park. Equipment in the buildings was removed and the facilities are in the process of decontamination. Results from monitoring these activities ranged from background levels up to five times the background levels, but the annual average concentrations appear to have remained below Clean Air Act Standards (10 mrem/yr).

The Hazardous Air Pollutants (HAPs) reports for metal monitoring at Y-12, ETTP, and Oak Ridge National Laboratory (ORNL) indicate no apparent elevated concentration of metals of concern. HAPs metals monitored were arsenic, beryllium, cadmium, total chromium, lead, nickel and uranium metal. Analyses for all metals of concern were below guidelines, and/or detection limits of laboratory analysis except for lead at ETTP and chromium at Y-12. Concentrations of lead in ambient air were comparable to those found in previous years. The atmospheric lead concentrations were also consistent with those reported by DOE for past years. The chromium value is consistent with historically measured values of total atmospheric chromium seen sporadically (about once per year) during past monitoring at Y-12 and ORNL.

Biological/Fish and Wildlife

Contaminants in Fish Tissue During 2003, the division proposed largemouth bass (*Micropterus salmoides*) fish tissue analysis to further substantiate collections and data used to determine local fishing advisories. Since this species is a popular sport fish and past evaluations have not adequately included it, the division analyzed bass through a cooperative effort with the Tennessee Valley Authority (TVA). Largemouth bass were to be acquired from TVA at four locations around the ORR during their annual Black Bass Survey in order to compare results with action criteria. Tissue samples from these fish were then to be analyzed for contaminants of concern. Due to seasonal conditions, an insufficient number of specimens of adequate size were not obtainable. Therefore this project was not completed in 2004.

Canada Geese On June 24 and 25, 2004, the Tennessee Department of Environment and Conservation, DOE Oversight Division (the division) conducted oversight of the annual Canada Geese (*Branta canadensis*) monitoring project on the Oak Ridge Reservation (ORR). The objective of this study was to determine if geese are becoming contaminated on the ORR. The captured geese were transported to the Tennessee Wildlife Resources Association (TWRA) game check station on Bethel Valley Road and tested for radioactive contamination. None of the geese captured at this year showed elevated gamma counts above the 5 pCi/g game release level. Since no contaminated geese were captured, the DOE-Oversight Division did not conduct additional offsite sampling of Canada Geese.

Aquatic Macroinvertibrates Semi-quantitative benthic macroinvertebrate samples were collected from study sites on four streams impacted by Department of Energy (DOE) operations. Using the State of Tennessee standard operating procedures for macroinvertebrate surveys, samples were collected, processed, and analyzed using applicable metrics. A score was calculated from the metrics and a stream site health rating was assigned. In general, results showed signs of biotic improvement with increasing water quality downstream of DOE influences. Only two study sites had a stream rating as healthy as bioregion reference conditions. Continued benthic macroinvertebrate monitoring would more closely define impacts on the aquatic environment from DOE related activities. Assessments of DOE remedial activities and cleanup efforts can also be made from these data.

Invasive plant mapping of a Black Oak Ridge Conservation Easement was started to get a handle on the ecological health and possible future management needs. From this initial mapping effort, we observed that the majority of the exotic species occur along existing gravel roads, pine-beetle damaged pine plantations, and formerly disturbed sites. Here, the exotics have little competition for habitat space. However, in the case of Kudzu infestations it does not seem to matter about competition from native plants as this aggressive invader takes over all vegetation (living or dead), open space, etc. There are, however, infested locations in the backcountry away from roads or trails.

Drinking Water

Chlorine Residuals The monitoring activities through oversight and independent sampling of the sanitary water distribution systems on the ORR met the regulatory requirement of 0.2 mg/L for residual chlorine. No elevated levels of bacteria above the regulatory limits were reported. The Environmental Radiation Ambient Monitoring System (ERAMS) that samples from five local drinking water treatment plants indicate that radionuclides are well below regulatory criteria. However, tritium has historically been found in higher concentrations for the Gallaher water treatment plant than the four other systems monitored in the program. The plant is located about seven river miles downstream of White Oak Creek that drains the ORNL watersheds.

ORNL drinking water was sampled for radionuclides in facilities serviced by lines running through and near the highly contaminated High Flux Isotope Reactor (HFIR) plume at ORNL. This sampling addressed the possible infiltration of radiological contaminants into the ORNL drinking water distribution system in the vicinity of HFIR. Results of the sampling indicate that, at the time of sampling, there were no radiological contaminants in the drinking water system in the vicinity of HFIR.

Groundwater

Springs and Residential Wells The calendar year 2004 groundwater-sampling projects included eighteen (18) exit pathway springs and three (3) surface water sites integrated with groundwater. Residential wells are to be sampled on a request basis only starting this sampling year. There were no requests during calendar year 2004. Residential water sources will be monitored for the presence of DOE related nuclear isotopes. Exit pathway springs in the peripheral areas of the Oak Ridge Reservation were monitored for determination of quality and effectiveness of DOE's monitoring and surveillance programs. Residential wells in the past have showed no evidence of contamination. Spring sampling showed that contamination exists beyond mapped plume boundaries.

Radiation

Ambient Radiation The Tennessee Department of Environment and Conservation began monitoring ambient radiation levels on the Oak Ridge Reservation in 1995. The program provides estimates of the dose to members of the public from exposure to gamma and neutron radiation attributable to Department of Energy activities on the reservation and baseline values for measuring the need and effectiveness of remedial activities. In this effort, environmental dosimeters have been placed at selected locations on and near the reservation. Results from the dosimeters are compared to background values and the state dose limit for members of the public. While all the doses reported for 2004 at off-site locations were below the dose limit for members of the public, several locations that are considered to be potentially accessible to the public had results in excess of the limit. As in the past, doses above 100 mrem/yr. were associated with various sites located in access-restricted areas of the reservation. In this study period from January 2004 to January 2005, dose rates in excess of the 100-mrem/yr. state/federal exposure limit were observed at four of the five monitored cylinder yards. Significantly, DOE has removed about half of the inventory of outdoor stored uranium hexafluoride from ETTP. The K-1066 B Yard was emptied out mid-year, causing the total yearly dose rate to drop. This action, as shown, will dramatically reduce gamma radiation levels at ETTP.

Real Time Gamma Radiation The division maintained gamma exposure rate monitors at a background location (Fort Loudoun Dam), spent nuclear fuel wells at SWASA 5 North (ORNL), Y-12's Industrial Landfill, the 3513 Waste Holding Basin (ORNL), the Environmental Restoration Coal Yard Storage Area (ORNL), and the Environmental Management Waste Management Facility (Bear Creek Valley). Measurements collected from these sites ranged from 1 μR/hr to 1,720 μR/hr. The highest exposure rates were recorded at the Environmental Management Waste Management Facility, during delivery of wastes generated by the remediation of the Corehole 8 area at ORNL. While not a DOE requirement, the highest value (1720 μR/hr) approaches limits specified by state and Nuclear Regulatory Commission regulations requiring their licensees to conduct operations in such a manner that the external dose in any unrestricted area not exceed 2.0 mrem (approximately 2000 μR) in any one hour period.

Vegetation bioaccumulation of radionuclides and metals has been determined to warrant further investigations. Specifically, gross beta, zinc, arsenic, iron, chromium, lead, cobalt, copper, and nickel had elevated concentrations in several vegetation samples collected during 2004. A purpose of the study was to show that contaminated groundwater emerging from springs was also impacting aquatic plant species in the same sampling reach of the spring-fed creeks and streams. Concentrations suggest a correlation between groundwater and aquatic vegetation concentrations from the same spring monitoring locations. This project has inferences to both human and wildlife exposures

Radon in Bear Creek Burial Grounds In 2004, the Tennessee Department of Environment and Conservation, DOE Oversight Division (the division) continued a pilot study designed to assess the feasibility of monitoring radon at burial grounds on DOE's Oak Ridge Reservation. The project was prompted by a concern that the disposal of large amounts of uranium in reservation burial grounds may have resulted in elevated radon levels (radon is produced by the natural decay of radionuclides in the uranium decay series). The results from the initial study in 2001 indicated radon levels could be measured using the technique developed for the project, but the loss of some of the detectors and damage to others by insects or small animals introduced uncertainties that limited the use of the data. It was subsequently decided to continue the study, but deploy the detectors during the winter/spring months in an effort to avoid some of the problems encountered in 2001. In 2004, the third set of detectors was placed over the burial grounds in Bear Creek Valley, left in place for four months, then retrieved and analyzed. While the results for were much lower in 2004 as in 2003 than those in 2001, data from all efforts indicate that radon can be measured using the techniques developed for the project and that the radioactive gas concentration was higher over localized areas than the background measurements.

Facility Surveys Like other Department of Energy research facilities across the nation, the Oak Ridge Reservation released large quantities of chemical and radiological contamination into the surrounding environment during nearly five decades of nuclear weapons research and development. In response to this history, the Tennessee Department of Environment and Conservation's DOE Oversight Division (the division) developed a Facility Survey Program to document the histories of facilities on the Reservation. The Program looks at facilities' physical condition, inventories of hazardous chemical and radioactive materials, process history, levels of contamination, and present-day potential for release of contaminants to the environment under varying conditions ranging from catastrophic (i.e. tornado) to normal everyday working situations.

This broad-based assessment supports the objectives of Section 1.2.3 of the *Tennessee Oversight Agreement*, which was designed to inform local citizens and governments of the historic and present-day character of all operations on the Reservation. This information is also essential for local emergency planning purposes. Since 1994 the division's survey team has characterized 172 facilities and found that thirty five percent pose a relatively high potential for release of contaminants to the environment. In many cases, this high-potential-for-release relates to legacy contamination that escaped facilities through degraded infrastructures over decades of continual industrial use (e.g. leaking underground waste lines, substandard sumps and tanks, or ventilation ductwork). Since the inception of the program, DOE corrective actions (including demolitions) have removed twelve facilities from the division's list of "high" Potential Environmental Release (PER) facilities.

Beginning in 2002 the Facility Survey Program staff also began organized document reviews and visits to facilities that were targeted for demolition at the ORNL and Y-12. This activity was in response to formal, accelerated infrastructure reduction (demolition) programs at each of those sites. During 2004 staff made 463 visits before and during the demolition of 38 facilities.

Follow-up on Needed Maintenance Actions on Otherwise Clean Areas - The Oak Ridge Reservation (ORR) was placed on the National Priorities List (NPL) in 1989. The purpose of Footprint Reduction was to identify portions of the ORR that have not been environmentally impacted by past federal (Department of Energy – DOE) activities. The mission was to determine which land parcels could be conditionally released from Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements. CERCLA 120-(h) was used as the guideline by the footprint team for the footprint investigations.

The goal was further identified as reducing the size and configuration of the area of the ORR designated as part of the NPL site and determining a No Further Investigation (NFI) status. The land parcels were assigned numerical identifiers ranging from 1 through 20. The Tennessee Department of Environment and Conservation, DOE Oversight Division (the division) performed a radiological walkover and reconnaissance survey of each parcel and adjacent land. The investigation focused on identifying potential anthropogenic sources of contamination and exit pathway releases on the ORR, which could render the parcel(s) unfit for release. In summation, the division investigated 21,439 acres of ORR land during the footprint project. In performance of the field investigation work, certain maintenance action items were identified on the various land parcels, i.e., "study areas" (see Appendix I). The division clearly emphasized these concerns to DOE in each footprint study area report released to the public. This current project was to revisit these sites to determine if action had in fact been taken by DOE to rectify the problems and other division concerns. Official site visits were not performed as a routine manner for calendar year 2004. Instead spot checks were made during work on other projects. Unfortunately, due to budgetary cutbacks or prioritization changes on DOE's part, none of the maintenance action sites except for the SWMUs have received the requested attention or response.

Surplus Material Verifications A total of 21 radiological free release inspections were conducted at two of the three Oak Ridge Reservation (ORR) facilities. Those were at Y-12 and ORNL surplus sales prior to public auctions. No sales were conducted at the ETTP. No radiological contamination was discovered during the radiological monitoring.

UF_6 Cylinder Transportation Oversight Due to a manpower shortage in TEMA, plans were formulated in order to assist TEMA in providing transportation oversight for the shipping of UF_6 cylinders from ETTP to Portsmouth. At the time that the shipment campaign was ready to begin, TEMA had solved their manpower situation and assumed responsibility for the inspection process.

Surface Water

General ambient surface water analysis is a key component of environmental quality and impact assessment for rivers, streams, lakes, and impoundments. The DOE Oversight Division conducted sampling at 26 sites in 2004. The samples were analyzed for standard water quality parameters. Based on comparisons with the Tennessee Water Quality Criteria (TWQC) for recreation, none of the sites exceeded these criteria. It should be recognized that sites very close to or within contaminated burial areas were not part of this scope. Specialized surface water investigations aid in evaluating point and non-point sources.

Rain Event Surface Water Monitoring

Due to the presence of areas of extensive point and non-point source contamination on the Oak Ridge Reservation (ORR), there exists the potential for contamination to impact surface waters on the ORR during excessive rain events. These events could cause the displacement of contamination that would not normally impact streams around the ORR. To assess the degree of surface water impact caused by these rain events, a sampling of streams will be conducted following heavy rain events to determine the presence or absence of contaminants of concern**.**

Samples were collected at 6 sites on the Oak Ridge Reservation (ORR) in 2004 once per quarter following a qualifying rain event. Most results were consistent with results following a heavy rain, such as high bacteriological and dissolved residue results. One exception was elevated radiological results from Melton Branch. Results here were elevated due to remedial activities taking place in Melton Valley. Although radiological analytes were seen with relatively elevated numbers, the concentrations in White Oak Creek at the White Oak Dam were not above regulatory limits. Follow up sampling conducted at this site have shown decreasing levels of radiological contamination.

Sediment

Sediment analysis is a key component of environmental quality and impact assessment for aquatic ecosystems. The Tennessee Department of Environment and Conservation, DOE Oversight Division (the division) conducted sediment sampling at 28 sites in 2004. The sediments were analyzed for inorganics, organics, and radiological parameters. Since there are no federal or state sediment cleanup levels, the data were compared to the Department of Energy's (DOE) Preliminary Remediation Goals (PRGs) for use at the Department of Energy Oak Ridge Operations Office. Based on the designation of the water bodies involved, the values were compared to the recreational PRGs. Under recreational land use, individuals are assumed to be exposed to contaminated media while playing, fishing, hunting, or engaging in other outdoor activities. Exposure could result from ingestion of soil or sediment, inhalation of vapors from soil or sediment, dermal contact with soil or sediment, external exposure to ionizing radiation emitted from contaminants in soil or sediment, and consumption of fish. For the contaminants that were analyzed, the sediments showed no levels of concern for human health. These samples were taken under ambient conditions and not near or within contaminated burial grounds.

Conclusion

The 2004 monitoring results showed effort by DOE to improve the overall health of the public and the environment. Many of the pollutant anomalies measured were a result of remediation activities and resulting fugitive emissions. However, none of these resulted in an unacceptable risk to the public. The state recognizes that some releases are inevitable when environmental clean up is done. The overall benefit of cleanup out weighs the short-term negative impacts. There are still significant source terms of contaminants that could be released through failure of engineering and administrative controls. Additionally, sources of gamma radiation exposure still exist that must be effectively isolated from the public. It is necessary and prudent for the state and DOE to continue monitoring efforts to detect and evaluate as early as possible, potential releases and radiation that could affect the public.

Introduction

The Tennessee Department of Environment and Conservation (TDEC), DOE Oversight Division in accordance with the Tennessee Oversight Agreement Attachment A.7.2.2, is providing an annual environmental monitoring report of the results of its monitoring and analysis activities during the calendar year of 2004 for public distribution. The division was established in 1991 to administer the Tennessee Oversight Agreement and the CERCLA required Federal Facility Agreement. These agreements are designed to assure the citizens of Tennessee that the Department of Energy (DOE) is protecting their health, safety, and environment through existing programs and substantial new commitments.

This report consists of a series of individual reports that involve independent environmental monitoring by the division. The individual reports are organized by general areas of interest: Air Quality; Biological/Fish and Wildlife; Drinking Water; Groundwater; Radiation and Surface Water. Abstracts and conclusions are available in each report to provide a quick overview of the content and outcome of each monitoring effort. All supporting information and data used in the completion of these reports are available for review in the division's program files. Overall, this report characterizes and evaluates the chemical and radiological emissions in the air, water, and sediments both on and off the Oak Ridge Reservation (ORR).

TDEC has considered the location, environmental setting, history, and on-going DOE operations in its environmental monitoring programs. The information gathered provides information for a better understanding of the fate and transport of contaminants released from the Oak Ridge Reservation into the environment. This understanding has led to the development of an ambient monitoring system and increased the probability of detecting releases in the event that institutional controls on the Oak Ridge Reservation fail.

Currently, TDEC's monitoring activities have not detected any imminent threats to public health or the environment outside of the Oak Ridge Reservation. Unacceptable releases of contaminants from past DOE operational and disposal activities continue to pose risk to the environment and it is imperative to note that if current institutional controls fail or if the present contaminant source controls can no longer be maintained, the public would be at risk of environmental contamination.

Site Description

The DOE Oak Ridge Reservation (ORR), as shown in Figure 1, encompasses approximately 35,000 acres and three major operational DOE facilities: the Oak Ridge National Laboratory (ORNL), the Oak Ridge Y-12 Plant (Y-12), and the East Tennessee Technology Park (ETTP, formerly the K-25 Gaseous Diffusion Plant). The initial objectives of the ORR operations were the production of plutonium and the enrichment of uranium for nuclear weapons components. In the 60 + years since the ORR was established, a variety of production and research activities have generated numerous radioactive, hazardous, and mixed wastes. These wastes, along with wastes from other locations, were disposed of on the ORR. Early waste disposal methods on the ORR were rudimentary compared to today's standards.

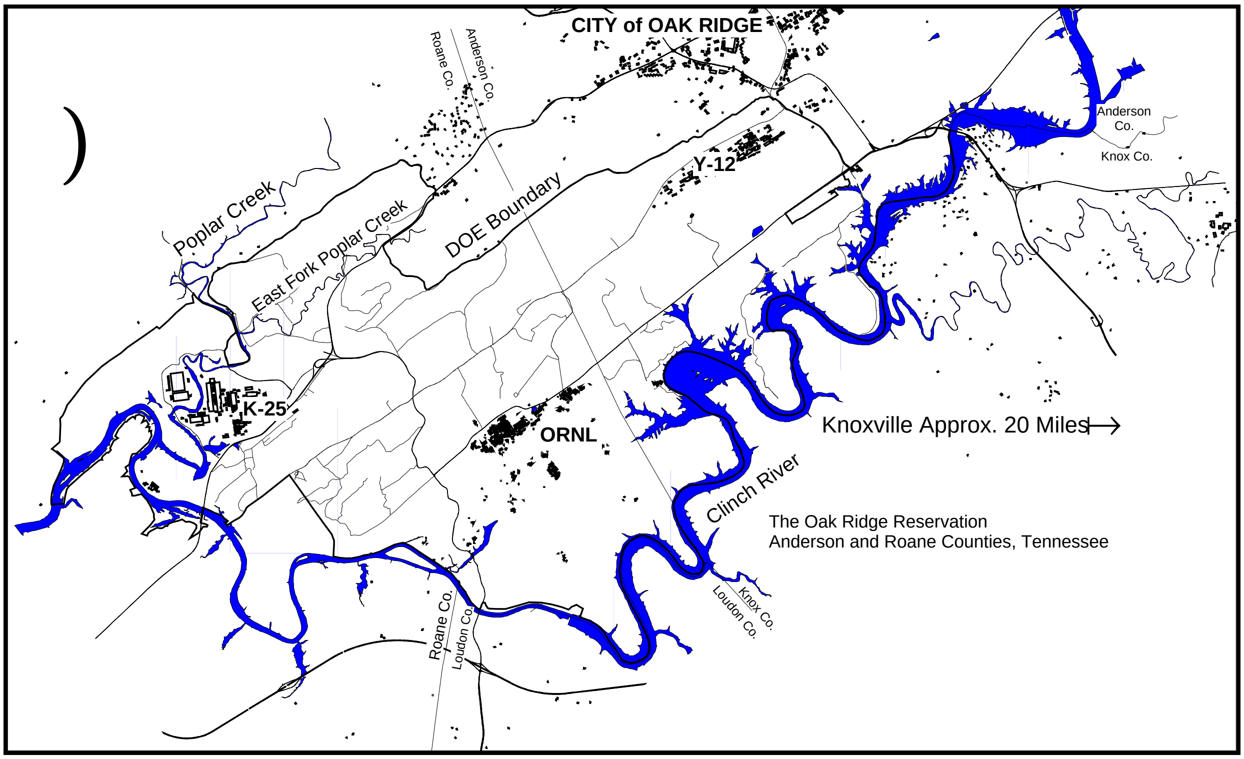

Figure 1: The Oak Ridge Reservation

The ORR is located within the corporate boundaries of the city of Oak Ridge, Tennessee, in the counties of Anderson and Roane. The Reservation is bounded on the north and east by residential areas of the city of Oak Ridge and on the south and west by the Clinch River. Counties adjacent to the Reservation include Knox, Loudon, and Morgan. Meigs and Rhea counties are immediately downstream on the Tennessee River from the ORR. The nearest cities are Oak Ridge, Oliver Springs, Kingston, Lenoir City, Harriman, Farragut, and Clinton. The nearest metropolitan area, Knoxville, lies approximately 20 miles to the east. Figure 2 depicts the general location of the Oak Ridge Reservation and nearby cities.

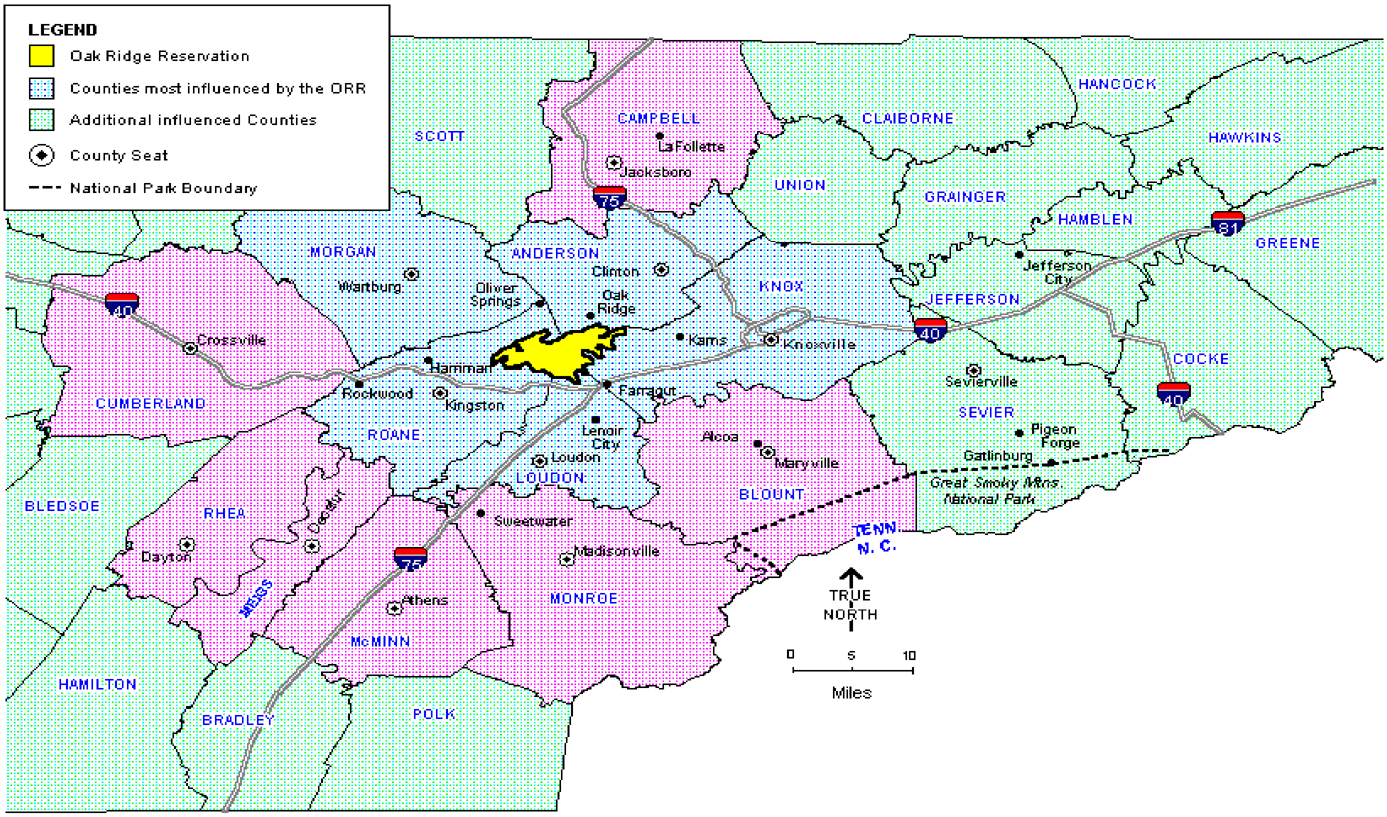

Figure 2: Location of the Oak Ridge Reservation

The ORR lies in the Valley and Ridge Physiographic Province of East Tennessee. The Valley and Ridge Province is a zone of complex geologic structures dominated by a series of thrust faults and characterized by a succession of elongated southwest-northeast trending valleys and ridges. In general, sandstones, limestones, and/or dolomites underlie the ridges that are relatively resistant to erosion. Weaker shales and more soluble carbonate rock units underlie the valleys.

The hydrogeology of the ORR is very complex with a number of variables influencing the direction, quantity, and velocity of groundwater flow that may or may not be evident from surface topography. In many areas of the ORR, groundwater appears to travel primarily along short flow paths in the storm flow zone to nearby streams. In other areas, evidence indicates substantial groundwater flow paths and, thereby, contaminant transport may occur preferentially in fractures and solution cavities in the bedrock for relatively long distances.

As seen in Figure 3, streams on the ORR drain to the Clinch River. Melton Hill Dam impounded the Clinch River in 1963. Contaminants released on the Oak Ridge Reservation enter area streams (e.g., White Oak Creek, Bear Creek, East Fork Poplar Creek, and Poplar Creek) and are transported into the Clinch River and Watts Bar Reservoir on the Tennessee River.

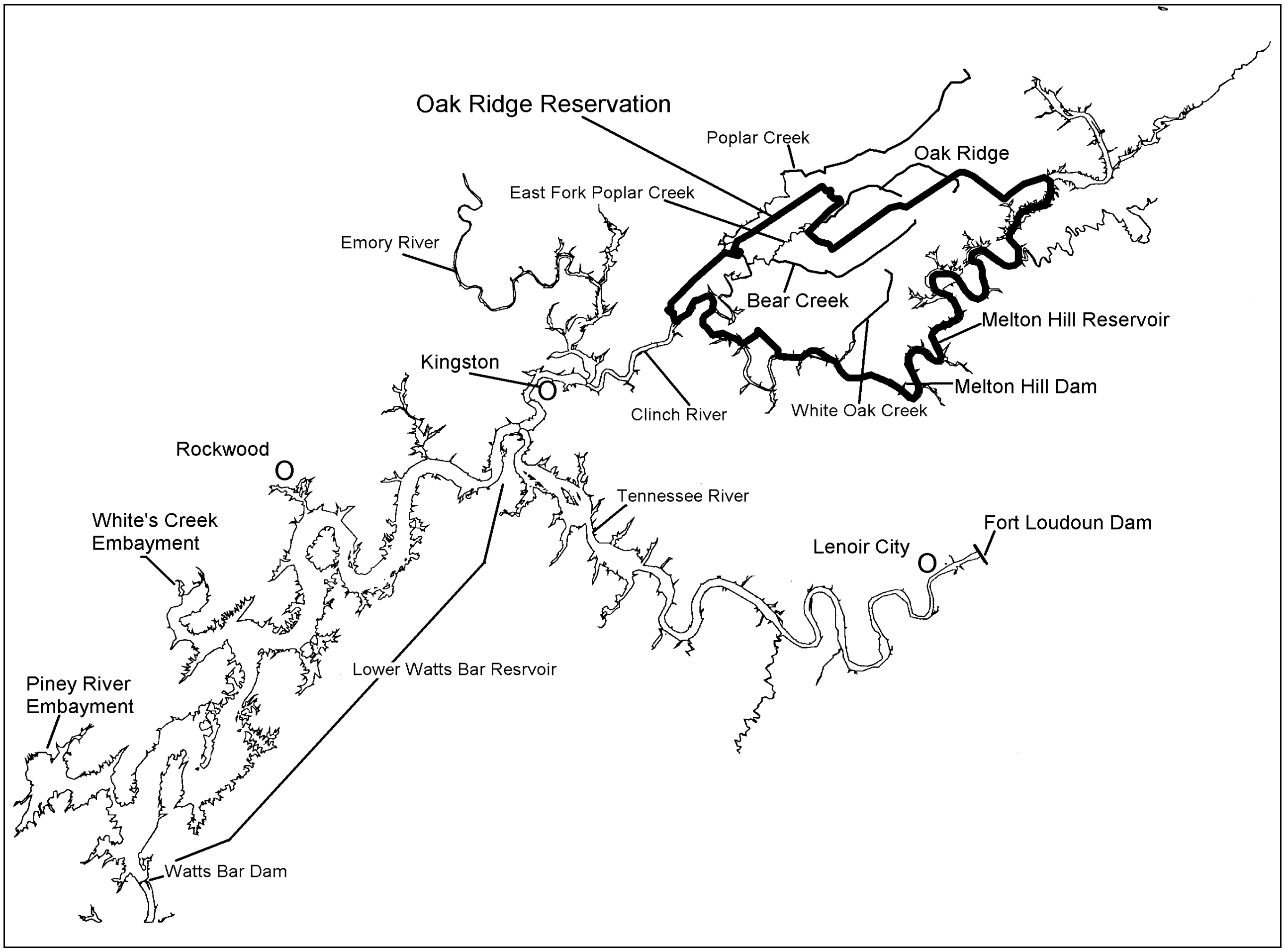

Figure 3: Watts Bar Reservoir

The climate of the region is moderately humid and the annual average precipitation is around 55 inches. Winds on the reservation are controlled, in large part, by the valley and ridge topography with prevailing winds moving up the valleys (northeasterly) during the daytime and down the valleys (southwesterly) at night.

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Chapter 1 AIR QUALITY MONITORING

Hazardous Air Pollutants Metals Monitoring on East Tennessee Technology Park

Principal Author: Sid Jones

Abstract

The Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division's (DOE-O) Hazardous Air Pollutant (HAPs) Monitoring Program was developed to provide continued independent monitoring at the East Tennessee Technology Park (ETTP) and to verify the Department of Energy's (DOE) reported monitoring results. Monitoring was conducted for Arsenic, Beryllium, Cadmium, Total Chromium, Lead, Nickel, and Uranium as a metal.

The results of the 2004 monitoring conducted by TDEC at the ETTP sites indicate no apparent elevated levels of for hazardous air pollutants (HAPs) metals of concern. Analytical results for all metals of concern except lead were below the detection limits of laboratory analysis. Detection limits were less than the risk specific dose listed in 40 CFR 266 Appendix V except for Arsenic and Chromium. Concentrations of lead in ambient air were comparable to those found in previous years. The atmospheric lead concentrations were also consistent with those reported by DOE for past years.

This project will continue to monitor for potential effects on the ORR at ETTP in order to provide independent monitoring to assure protection of human health and the environment. In the future, analytical limits for arsenic and chromium will be improved to facilitate a more meaningful comparison with the risk specific dose.

Introduction

This independent monitoring project is conducted under authority of the Tennessee Oversight Agreement. It is a continuation of the ambient air-monitoring project initiated in 1997 in response to the heightened level of public concern regarding potential impacts to public health from the TSCA Incinerator emissions. Additionally, with the continuation of D&D activities as at the site, further analyses of the potential impacts, if any, of these projects on the ambient air on and around the ETTP site is warranted.

Title III of the Clean Air Act Amendments (CAAAs) has identified 189 toxic chemicals. These chemicals, called hazardous air pollutants, or HAPs, are known or suspected carcinogens, and have high usage and emissions in a wide variety of industries. Major stationary sources of HAPs are subject to the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) found in Title III of the CAAAs of 1990. Rather than NESHAPs for each pollutant, the 1990 CAAAs direct EPA to set technology-based standards using maximum achievable control technologies (MACT) for 175 source categories which will require sharp reductions of routine emissions of toxic air pollutants.

In 1997, concerns were raised by members of the public regarding potential health effects due to possible concentrations of HAPs in the ambient air on and around ORR. In response to these concerns, TDEC/DOE-O's Waste Management (WM) program developed an ambient air monitoring program for the ORR in order to determine what effects, if any, DOE operations were having on the ambient air on and around the reservation with regard to HAPs. This program was designed to provide an independent verification of monitoring results as reported by the DOE. Background data was collected at a site located near Norris Lake. This data was used in a comparative manner as a baseline for the area surrounding the ORR. Nickel and Uranium as a metal were added in 1999 to the list of metals of concern. Future Decontamination and Decommissioning (D&D) activities that could possibly generate emissions of HAPs will continue to be evaluated and monitored as required by TDEC.

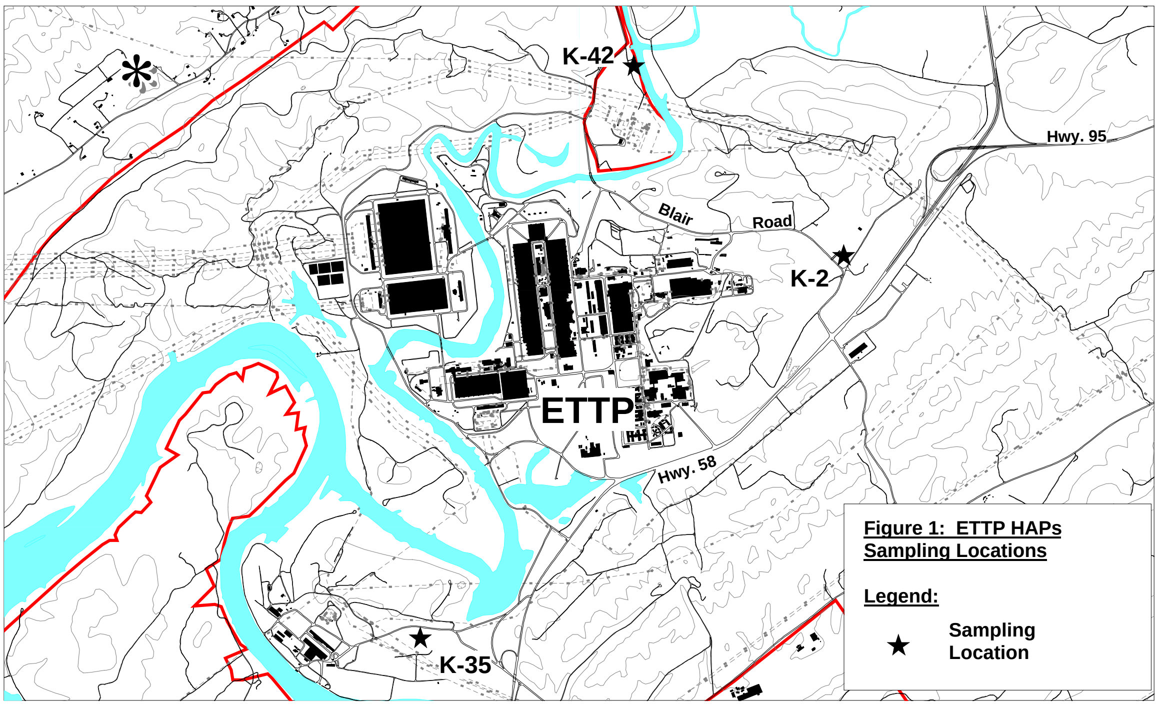

Figure 1: ETTP HAPs Sampling Locations

ETTP

Methods and Materials

The ambient air sampling for this project was conducted at stations K-2 (Blair Road opposite the TSCA Incinerator), station K-42 co-located with DOE Perimeter Air Monitor (PAM) 42 (next to Poplar Creek) and station K-35 co-located with DOE Perimeter Air Monitor (PAM) 35 (Gallaher Rd Bridge area). The locations of these monitoring stations are shown in Fig. 1. The same sites were also utilized for the previous TDEC monitoring.

The monitoring sites selected were chosen based upon windroses data that indicated the sites were in the prevailing wind flow patterns for the region surrounding the ORR. The windflow during the day is a southwest to northeast pattern while during the night; the flow pattern is reversed. The placement then of TDEC's monitors allowed for sampling that would be representative of a 24-hour windflow pattern at the ORR. Additional factor in selecting these locations was an availability of power source.

The monitoring schedule was modified somewhat in 2004, based on past sampling results and data reported in the Oak Ridge Reservation Annual Site Environmental Report (ASER). These data indicate that both lead and uranium average values are typically highest at the K-2 site. Of the 46 weeks for which data was collected in 2004, the sampler was located at the K-2 site approximately half of the time. The schedule was also modified to accommodate down time due to monitor maintenance and other events that effected movement of the samplers. Typically, filter samples were collected on a weekly basis and mailed to the state laboratory in Nashville for analysis. The actual sampling schedule throughout 2004 is given below in Table 1.

Table 1.
2004 HAPs metals ambient air sampling schedule

Monitoring period[1]	Sampling Locations	Sampling period	Collection frequency	Analysis frequency
01/01/04-01/07/04	K-35	Continuous	Weekly	Weekly
01/07/04-02/11/04	K-42	Continuous	Weekly	Weekly
02/11/04-03/11/04	K-2	Continuous	Weekly	Weekly
03/11/04-04/15/04	K-35	Continuous	Weekly	Weekly
04/15/04-05/27/04	K-42	Continuous	Weekly	Weekly
05/27/04-06/17/04	K-2	Continuous	Weekly	Weekly
06/17/04-07/28/04	K-35	Continuous	Weekly	Weekly
07/28/04-12/17/04	K-2	Continuous	Weekly	Weekly

[1]Sampler rotated between K-2, K-42, and K-35 monitoring locations.

Results and Discussion

Quarterly results for lead were determined from analyses of continuous weekly samples from stations K-2, K-35, and K-42. Lead analytical results are summarized in Table 2 and are compared with the Tennessee and national quarterly ambient air quality standard of 1.5 μg/m^3. The results obtained indicate that this value was less than 1% of the quarterly standard.

At the time of this report, the ORR Annual Site Environmental Report (ASER) for 2004 was not available. However, analytical results from the 2001, 2002 and 2003 HAPs monitoring program were compared with results from the 2001, 2002 and 2003 ASERs indicating comparable levels of HAPs in the ambient air in and around the ORR.

Table 2
2004 Lead concentration in ambient air at the ETTP

Station	**Quarterly averages of weekly samples (μg/m^3)**				**Max quarterly result (μg/m^3)**	**Max weekly result (μg/m^3)**	**Max percent of quarterly standard (μg/m^3)[a]**
	1	**2**	**3**	**4**			
K-2	0.005	*b*	0.003	0.004	0.005	0.008	<1
K-35	0.004	0.003	0.002	*b*	0.004	0.005	<1
K-42	0.003	0.002	*b*	*b*	0.003	0.004	<1
Quarterly max	0.005	0.003	0.003	0.004	0.005	N/A	<1
Tennessee and national quarterly ambient air quality standard of 1.5 μg/m^3							
Annual average for all stations = 0.0030 μg/m^3							

[a] Tennessee and national air quality standard for lead is 1.5 μg/m^3 quarterly arithmetic average.
[b] This station was not monitored this quarter.

Analyses of hazardous air pollutant carcinogenic metals (arsenic, beryllium, cadmium, chromium, and nickel) were performed on all collected continuous weekly samples from stations K-2, K-35, and K-42. These analytical results are summarized in Table 3. There were no detected concentrations of arsenic, beryllium, cadmium, chromium or uranium. There are no Tennessee or national ambient air quality standards for these hazardous air pollutants. The annual average concentrations were compared to risk specific doses and reference air concentrations as listed in 40 CFR 266.

At the time of this report, the ORR Annual Site Environmental Report (ASER) for 2004 was not available. However, analytical results from the 2001, 2002 and 2003 HAPs monitoring program were compared with the 2001, 2002, and 2003 ASERs. The 2001 ASER indicated detection of hazardous air pollutant carcinogenic metals with all of them below the risk-specific doses. Laboratory analyses for the air data reported in the DOE ASER were done using inductively coupled plasma mass spectrometry (ICP-MS), yielding better detection limits, especially for arsenic and chromium. Nickel was not included as a monitoring parameter in the ASER.

Table 3.
2004 Hazardous air pollutant carcinogenic metals concentration in ambient air at the ETTP

HAPs	**Ambient air concentration (μg/m^3)**			**Annual concentration guideline (μg/m^3)**	**Minimum detection limit (μg/m^3)**
	Annual avg.	**Weekly max**	**Max location**		
Arsenic	U	U	NA	0.0023[a]	0.01
Beryllium	U	U	NA	0.004[a]	0.001
Cadmium	U	U	NA	0.0056[a]	0.001
Chromium	U	U	NA	0.00083[a] Cr-VI 1000.0[a] Cr-III	NA
Nickel	U	U	NA	0.042[a]	0.001
Uranium	U	U	NA	0.15[b]	0.01

U – Analyte not detected in laboratory analysis

[a] Risk-specific doses for As, Be, Cd, Cr-VI, and Ni and the reference air concentration for Cr-III as listed in 40 CFR 266, Appendix V.

[b] DOE Order 5400.5 Derived Concentration Guide (DCG) for naturally occurring uranium is an annual concentration of 1E-01 pCi/m^3, which is equivalent to 100 mrem annual inhalation dose. This is equivalent to 0.15 ug/m^3 assuming mass-to-curie concentration conversion for natural uranium assay of 0.717% ^{235}U.

Conclusion

The results of the 2004 monitoring conducted by TDEC at the ETTP sites indicate no apparent elevated levels of for hazardous air pollutants (HAPs) metals of concern. Analyses for all metals of concern were below guidelines, and/or detection limits of laboratory analysis. This project has been re-authorized to continue into 2005. In 2005, the K-2 site will be monitored continuously and monitoring at the other sites will be dropped. The minimum analytical detection limits for arsenic and chromium will be evaluated by the analytical laboratory, and, if necessary, another method of analysis may be used to improve detection.

References

Boiler and Industrial Furnace Regulations - 40 CFR Part 266. Appendix V.

Draft New York State Air Guide-1, Guidelines for the Control of Toxic Ambient Air Contaminants, Appendix B of Air Guide-1, Ambient Air Quality Impact Screening Analyses, 1994 Edition.

Operations Manual for GMW Model2000H Total Suspended Particulate Sampling System, 1998 Graseby GMW Variable Resistance Calibration Kit # G2835.

TDEC/DOE-O Procedure number: SOP-ES&H-004 Air Monitoring/Air Sampling

Yard, C.R. 2002 *Health, Safety and Security Plan*, Tennessee Department of Environment and Conservation Department of Energy Oversight Division, Oak Ridge, Tennessee.

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CHAPTER 1 AIR QUALITY MONITORING

Hazardous Air Pollutants Metals Monitoring on Y-12 and ORNL (X-10)

Principal Author: Sid Jones

Abstract

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division's (the division) Hazardous Air Pollutant (HAPs) Monitoring Program was developed to provide continued independent monitoring of hazardous metals in ambient air at the Oak Ridge National Lab (ORNL or X-10) and Y-12 National Security Complex (Y-12). Monitoring with high volume air samplers was conducted for Arsenic, Beryllium, Cadmium, Total Chromium, Lead, Nickel, and Uranium as a metal.

Although a number of potential sources that have the potential to emit hazardous metals are located on and around the Oak Ridge Reservation (ORR), the results of the 2004 monitoring conducted by TDEC at the Y-12 and ORNL sites indicate no apparent elevated levels of for hazardous air pollutants (HAPs) metals of concern. With a single exception, analyses for all metals of concern were below guidelines and/or laboratory detection limits. On February 19, 2004, the weekly value for chromium at the monitoring station east of the Y-12 plant showed 0.003 $\mu g/m^3$; which is above the risk-specific dose for the more oxidized state of chromium (Cr VI), but less than the reference concentration for the more reduced chromium III. This value is consistent with historically measured values of total atmospheric chromium seen sporadically (about once per year) during past monitoring at Y-12 and ORNL. Currently, uncertainty regarding the laboratory detection levels for chromium and a lack of information on both the oxidation state and the primary sources of atmospheric chromium near the ORR prevent useful comparisons with the reference dose.

This project will continue to monitor for hazardous metals in ambient air on the ORR at Y-12 and ORNL. The goal is to provide independent air monitoring to assure protection of human health and the environment. Lower minimum detection limits for chromium and arsenic will be established in the future, and historical data generated by this office and by DOE will be reviewed to refine or change sampling techniques, analytical methods, or location of samplers.

Introduction

Title III of the Clean Air Amendments (CAAAs) identified 189 toxic chemicals. These chemicals, called hazardous air pollutants, or HAPs, are known or suspected carcinogens, and have high usage and emissions in a wide variety of industries. Major stationary sources of HAPs are subject to the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) found in Title III of the CAAAs of 1990. Rather than establishing NESHAPs for each pollutant, the 1990 CAAAs direct EPA to set technology-based standards using maximum achievable control technologies (MACT) for 175 source categories which will require sharp reductions of routine emissions of toxic air pollutants.

In 1997, concerns were raised by members of the public regarding potential health effects due to possible concentrations of HAPs in the ambient air on and around ORR. In response to these concerns, the division's Waste Management (WM) program developed an ambient air monitoring program for the ORR in order to determine what effects, if any, DOE operations were having on the ambient air on and around the reservation with regard to HAPs. This program was designed to provide an independent verification of monitoring results as reported by the DOE. Background data was collected at a site located near Norris Lake. This data was used in a comparative manner as a baseline for the area surrounding the ORR. Nickel and Uranium as a metal were added in 1999 to the list of metals of concern.

ORNL

Monitoring at ORNL was conducted at stations located at both the east and west ends of this facility. The western site is co-located at the Perimeter Air Monitor (PAM) 3 off Bethel Valley Road. The monitor at the east end of ORNL is co-located with Meteorological Tower 3. See Figure 1.

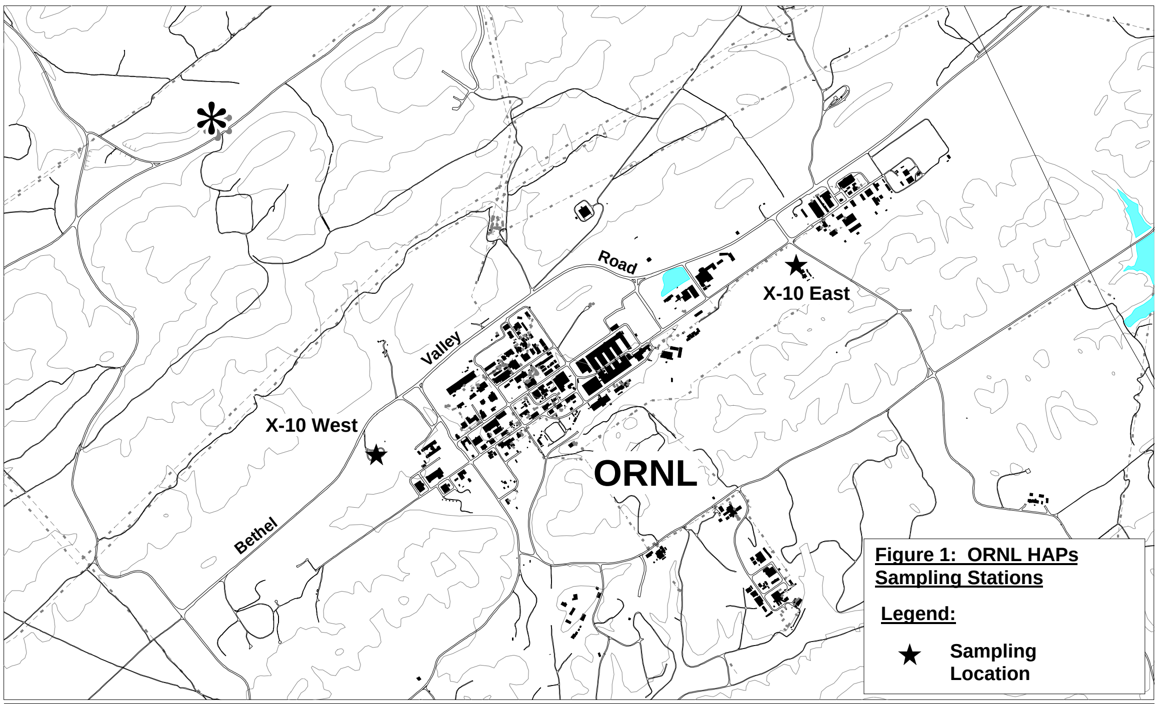

Figure 1: ORNL HAPs Sampling Stations

Y12

Monitoring at Y-12 was conducted at stations located at both the east and west ends of this facility. The site at the west-end of Y-12 is co-located with Meteorological Tower 6 on Bear Creek Valley Road. The monitoring site at the east end of Y-12 is co-located with Meteorological Tower 5. See Figure 2.

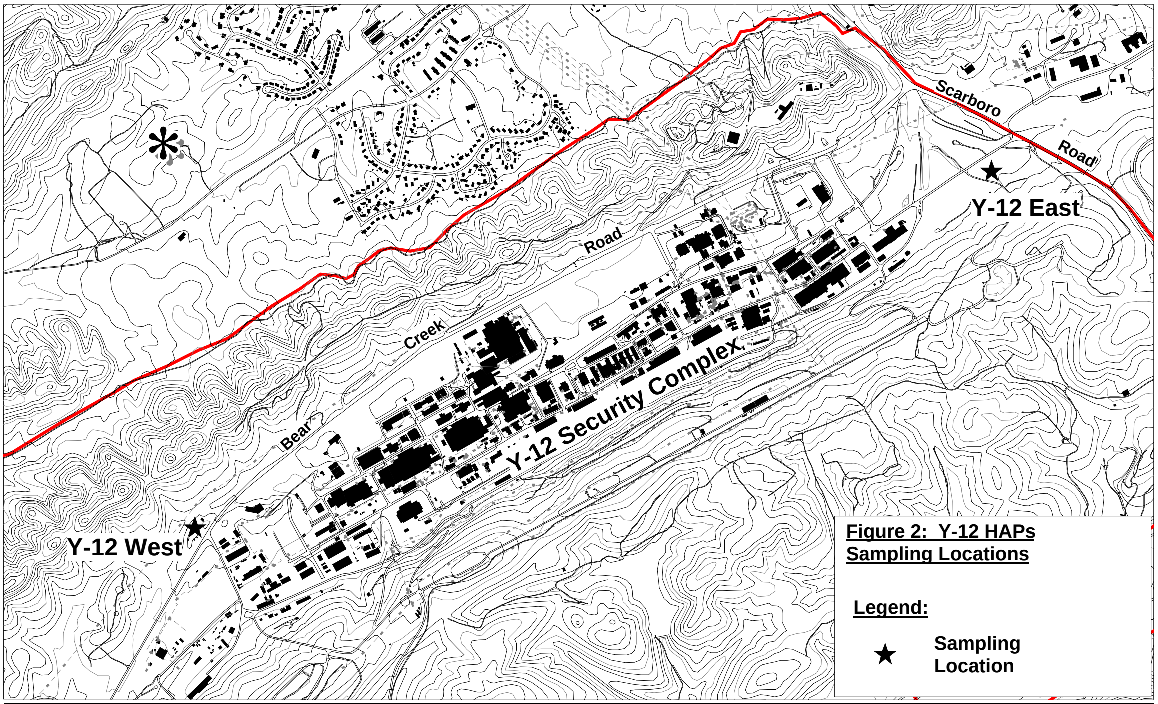

Figure 2: Y-12 HAPs Sampling Locations

Methods and Materials

The monitoring sites selected were chosen based upon windroses data that indicated the sites were in the prevailing wind flow patterns for the region surrounding the ORR. The windflow during the day is a southwest to northeast pattern while during the night; the flow pattern is reversed. The placement then of TDEC's monitors allowed for sampling that would be representative of a 24-hour windflow pattern at the ORR. Additional factor in selecting these locations was an availability of power source.

The project was conducted as closely as possible to the established 2004 sampling project schedule. Filter samples were collected on a weekly basis and mailed to the state laboratory in Nashville for analysis. The principal parameters monitored during 2004 were arsenic, beryllium, cadmium, total chromium, lead, nickel, and uranium. Uranium was analyzed as a metal (by inorganic method). The ambient air sampling schedules for ORNL and Y-12 are listed in Table 1 and Table 2, respectively.

Results and Discussion

Table 1.
2004 HAPs metals ambient air sampling schedule at ORNL

Monitoring period[1]	Sampling Locations	Sampling period	Collection frequency	Analysis frequency
01/01/04-01/07/04	X-10 E	Continuous	Weekly	Weekly
01/07/04-2/11/04	X-10 W	Continuous	Weekly	Weekly
2/19/04-3/25/04	X-10 E	Continuous	Weekly	Weekly
03/25/04-04/07/04	X-10 W	Continuous	Weekly	Weekly
04/22/04-05/27/04	X-10 E	Continuous	Weekly	Weekly
05/27/04-06/23/04	X-10 W	Continuous	Weekly	Weekly
06/23/04-07/28/04	X-10 E	Continuous	Weekly	Weekly
07/28/0-09/29/04	X-10 W	Continuous	Weekly	Weekly
09/29/04-12/17/04	X-10 E	Continuous	Weekly	Weekly
12/21/04-12/30/04	X-10 W	Continuous	Weekly	Weekly

[1]Sampler rotated between X-10 E and X-10 W monitoring locations.

Table 2.
2004 HAPs metals ambient air sampling schedule at Y-12

Monitoring period[1]	Sampling Locations	Sampling period	Collection frequency	Analysis frequency
01/01/04-01/07/04	Y-12 E	Continuous	Weekly	Weekly
01/07/04-2/11/04	Y-12 W	Continuous	Weekly	Weekly
2/11/04-3/18/04	Y-12 E	Continuous	Weekly	Weekly
03/18/04-04/07/04	Y-12 W	Continuous	Weekly	Weekly
04/22/04-05/27/04	Y-12 E	Continuous	Weekly	Weekly
05/27/04-06/23/04	Y-12 W	Continuous	Weekly	Weekly
06/23/04-07/28/04	Y-12 E	Continuous	Weekly	Weekly
07/28/0-09/29/04	Y-12 W	Continuous	Weekly	Weekly
09/29/04-12/17/04	Y-12 E	Continuous	Weekly	Weekly
12/17/04-12/30/04	Y-12 W	Continuous	Weekly	Weekly

[1]Sampler rotated between Y-12 E and Y-12 W monitoring locations.

Quarterly lead results were determined from analyses of continuous weekly samples from stations X-10 E and X-10 W at ORNL and from stations Y-12 E and Y-12 W at the Y-12 site. Lead analytical results are summarized in Table 3 and Table 4 and are compared with the Tennessee and national quarterly ambient air quality standard of 1.5 $\mu g/m^3$. At both ORNL and Y-12 the results obtained indicate that this value was only <1% of the quarterly standard.

At the time of this report, the ORR Annual Site Environmental Report (ASER) for 2004 was not available. However, analytical results from the 2001, 2002 and 2003 HAPs monitoring program were compared with the 2001, 2002, and 2003 ASERs indicating comparable levels of HAPs in the ambient air in and around the ORR.

Table 3.
2004 Lead concentration in ambient air at ORNL

Station	Quarterly averages of weekly samples (µg/m³)				Max quarterly average (µg/m³)	Max weekly result (µg/m³)	Max percent of quarterly standard (µg/m³)[a]
	1	2	3	4			
X-10 E	0.004	0.003	0.003	0.004	0.004	0.007	<1
X-10 W	0.003	0.002	0.003	0.001	0.003	0.006	<1
Weekly max	0.007	0.005	0.006	0.006	0.005	N/A	<1
Tennessee and national quarterly ambient air quality standard of 1.5 µg/m³							
Annual average for all stations = 0.003 µg/m³							

[a] Tennessee and national air quality standard for lead is 1.5 µg/m³ quarterly arithmetic average.

Table 4.
2004 Lead concentration in ambient air at Y-12

Station	Quarterly averages of weekly samples (µg/m³)				Max quarterly average (µg/m³)	Max weekly result (µg/m³)	Max percent of quarterly standard (µg/m³)[a]
	1	2	3	4			
Y-12 E	0.004	0.003	0.003	0.004	0.004	0.008	<1
Y-12 W	0.003	0.002	0.003	0.006	0.006	0.009	<1
Weekly max	0.005	0.004	0.007	0.009		N/A	<1
Tennessee and national quarterly ambient air quality standard of 1.5 µg/m³							
Annual average for all stations = 0.003 µg/m³							

[a] Tennessee and national air quality standard for lead is 1.5 µg/m³ quarterly arithmetic average.
[b] This station was not monitored this quarter.

Analyses of hazardous air pollutant carcinogenic metals (arsenic, beryllium, cadmium, chromium, and nickel) were performed on all collected continuous weekly samples from stations X-10 E and X-10 W at ORNL and from stations Y-12 E and Y-12 W at the Y-12 site. These analytical results are summarized in Table 5 and Table 6. There are no Tennessee or national ambient air quality standards for these hazardous air pollutants. The average concentrations were compared to risk specific doses and reference air concentrations as listed in 40 CFR 266, Appendix V.

There were no detected concentrations of arsenic, beryllium, cadmium, and uranium. Nickel was not detected in 2004 at X-10, but was detected twice at the detection limit of 0.001 µg/m3 at Y-12, well below the risk-specific dose of 0.042 µg/m3. The only result for chromium was at Y-12, where a result of .003 µg/m3 was measured for the sampling period of 2/11/04-2/19/04. This value is above the risk-specific dose for the more oxidized state of chromium (Cr VI), but less than the reference concentration for the more reduced chromium III. This value is consistent with historically measured values of total atmospheric chromium seen sporadically (about once per year) during past monitoring at Y-12 and ORNL. Currently, uncertainty regarding the laboratory detection levels for chromium and a lack of information on both the oxidation state and the primary sources of atmospheric chromium near the ORR prevent useful comparisons with the reference dose.

At the time of this report, the ORR Annual Site Environmental Report (ASER) for 2004 was not available. However, analytical results from the 2001, 2002 and 2003 HAPs monitoring program were compared with the 2001, 2002 and 2003 ASERs. The ASER data indicated detection of hazardous air pollutant carcinogenic metals with all of them below the risk-specific doses. Nickel was not included as a monitoring parameter in the ASER. The maximum concentration of uranium was reported, by DOE in the 2002 ASER, as less than 1% of Derived Concentration Guide of $0.15 \mu g/m^3$.

Table 5.
2004 Hazardous air pollutant carcinogenic metals concentration in ambient air at ORNL

HAPs	Ambient air concentration ($\mu g/m^3$)			Annual concentration guideline ($\mu g/m^3$)	Percentage of standard (guideline)
	Annual avg.	Weekly max	Max location		
Arsenic	U	U		0.0023[a]	0
Beryllium	U	U		0.004[a]	0
Cadmium	U	U		0.0056[a]	0
Chromium	U	U		0.00083[a] Cr-VI 1000.0[a] Cr-III	NA
Nickel	U	U		0.042[a]	0
Uranium	U	U		0.15[b]	0

U – Analyte not detected in laboratory analysis

[a] Risk-specific doses for As, Be, Cd, Cr-VI, and Ni and the reference air concentration for Cr-III as listed in 40 CFR 266.

[b] DOE Order 5400.5 Derived Concentration Guide (DCG) for naturally occurring uranium is an annual concentration of 1E-01 pCi/m^3, which is equivalent to 100 mrem annual inhalation dose. This is equivalent to 0.15 ug/m^3 assuming mass-to-curie concentration conversion for natural uranium assay of 0.717% ^{235}U.

Table 6.
2004 Hazardous air pollutant carcinogenic metals concentration in ambient air at Y-12

HAPs	Ambient air concentration ($\mu g/m^3$)			Annual concentration guideline ($\mu g/m^3$)	Percentage of standard (guideline)
	Annual avg.	Weekly max	Max location		
Arsenic	U	U		0.0023[a]	0
Beryllium	U	U		0.004[a]	0
Cadmium	U	U		0.0056[a]	0
Chromium	NA	.003		0.00083[a] Cr-VI 1000.0[a] Cr-III	NA
Nickel	NA	0.001	Y12E, Y12W	0.042[a]	0
Uranium	U	U		0.15[b]	0

U – Analyte not detected in laboratory analysis

[a] Risk-specific doses for As, Be, Cd, Cr-VI, and Ni and the reference air concentration for Cr-III as listed in 40 CFR 266.

[b] DOE Order 5400.5 Derived Concentration Guide (DCG) for naturally occurring uranium is an annual concentration of 1E-01 pCi/m^3, which is equivalent to 100 mrem annual inhalation dose. This is equivalent to 0.15 ug/m^3 assuming mass-to-curie concentration conversion for natural uranium assay of 0.717% ^{235}U.

Conclusion

The results of the 2004 monitoring conducted by TDEC at ORNL and Y-12 sites indicate no apparent elevated levels of for hazardous air pollutants (HAPs) metals of concern. Analyses for all metals of concern were below guidelines, and/or detection limits of laboratory analysis. However, laboratory detection limits must be improved for arsenic and chromium before meaningful comparisons can be made between the results and risk-specific doses listed in 40 CFR 266 for these two metals. This project has been re-authorized to continue into 2005. Sampling sites will remain as they have for the year 2004, and detection limits for certain metals will be evaluated by the laboratory.

References

Boiler and Industrial Furnace Regulations - 40 CFR Part 266. Appendix V.

Draft New York State Air Guide-1, Guidelines for the Control of Toxic Ambient Air Contaminants, Appendix B of Air Guide-1, Ambient Air Quality Impact Screening Analyses, 1994 Edition.

Operations Manual for GMW Model2000H Total Suspended Particulate Sampling System, 1998 Graseby GMW Variable Resistance Calibration Kit # G2835.

TDEC/DOE-O Procedure number: SOP-ES&H-004 Air Monitoring/Air Sampling.

Yard, C.R. 2002 *Health, Safety and Security Plan*, Tennessee Department of Environment and Conservation Department of Energy Oversight Division, Oak Ridge, Tennessee

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CHAPTER 1 AIR QUALITY MONITORING

Environmental Radiation Ambient Monitoring System (ERAMS) Air Program

Principal Authors: Natalie Pheasant, Howard Crabtree

Abstract
The Environmental Protection Agency's Environmental Radiation Ambient Monitoring System (ERAMS) is designed to monitor potential pathways for significant population exposures from routine and/or accidental releases of radioactivity from major sources in the United States (EPA, 1988). This program provides radiochemical analysis of air samples taken from five air monitoring stations located on the Oak Ridge Reservation. In this effort, samples are collected twice weekly at each station by personnel from the Tennessee Department of Environment and Conservation to be analyzed at the EPA's National Air and Radiation Environmental Laboratory in Montgomery, Alabama. The results are provided to the state and published in a quarterly EPA report, *Environmental Radiation Data*. In 2004, the ERAMS results from each station exhibited similar trends and concentration. While slightly higher results were reported at monitoring locations near the Y-12 National Nuclear Security Complex, the available ERAMS results for 2004 do not indicate a significant impact on the environment or public health from ORR emissions.

Introduction
In the past, air emissions from Department of Energy (DOE) activities on the Oak Ridge Reservation (ORR) were believed to have been a potential cause of illnesses affecting area residents. While these emissions have substantially decreased over the years, concerns have remained that air pollutants from current activities (e.g., incineration of radioactive wastes, production of radioisotopes, and remedial activities) could pose a threat to public health and/or the surrounding environment. As a consequence, the Tennessee Department of Environment and Conservation (TDEC) has implemented three air monitoring programs to assess the impact of ORR air emissions on the surrounding environment and the effectiveness of DOE controls and monitoring systems. TDEC's Perimeter and Fugitive Air Monitoring Programs (described in associated reports) focus on monitoring exit pathways, non-point sources of emissions, and sites of special interest. TDEC's participation in the Environmental Protection Agency's (EPA) Environmental Radiation Ambient Monitoring System (ERAMS) supplements the other programs and provides verification of state and DOE monitoring.

EPA's ERAMS program is comprised of a national network of monitoring stations that regularly collect samples of air, water, and milk for radiochemical analysis. Historically, this network has been used to track environmental releases of radioactivity from nuclear weapons tests and nuclear accidents. In response to TDEC requests and an initiative to incorporate site specific monitoring into the program, EPA agreed to locate five air monitoring stations on the ORR in December 1994. These stations began operation in 1996.

Methods and Materials
The approximate locations of the five ERAMS samplers are provided in Figure 1 and EPA's analytical parameters are listed Table 1. The ERAMS samplers run continuously, collecting suspended particulates on filters as air is pulled through the units by a pump. TDEC staff collect these synthetic fiber filters from each sampler twice weekly, estimate the radioactivity on each using TDEC detection equipment, then ship the filters to EPA's National Air and Radiation Environmental Laboratory (NAREL) in Montgomery, Alabama, for analysis.

NAREL performs gross beta analysis on each sample collected. Where the gross beta result exceeds one picocurie per meter cubed (pCi/m^3), additional analysis (gamma spectrometry) is performed to identify gamma emitters that may be present in the sample. Analysis for uranium and plutonium isotopes is performed annually on a composite of the air filters collected during year. The results of the NAREL analysis are provided to TDEC staff and published in quarterly reports (*Environmental Radiation Data*), which are available on NAREL's internet web site (http://www.epa.gov/narel/erams/erdonline.html).

In 2004, none of the gross beta results reported for the program exceeded the NAREL screening level that would have required analysis by gamma spectrometry. The 2004 results for uranium and plutonium analysis performed annually on composites of the air filters for each monitoring station was not available at the time of this report.

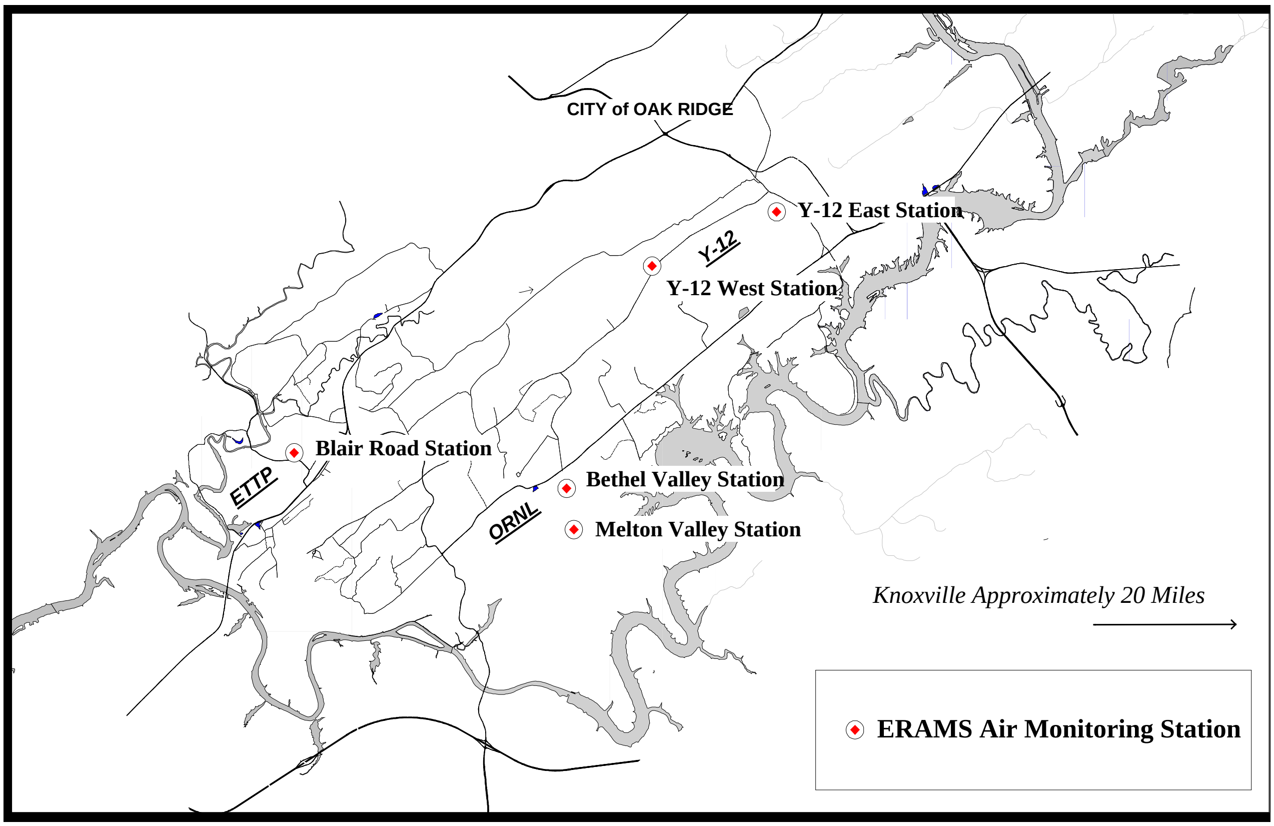


Figure 1: Approximate Locations of Air Stations Monitored in Association with EPA's Environmental Radiation Ambient Monitoring System on the Oak Ridge Reservation.

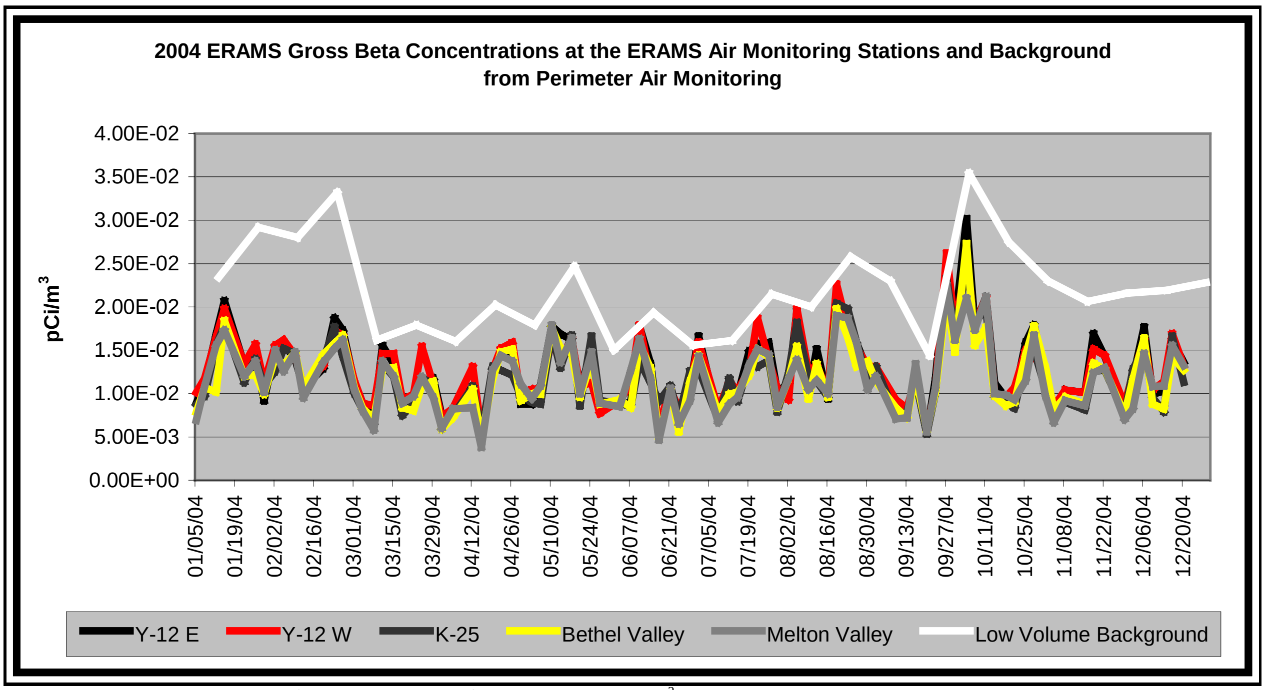
Table 1: EPA Analysis of Air Samples Taken in Association with the Environmental Radiation Ambient Monitoring System

ANALYSIS	FREQUENCY
Gross Beta	Each sample, twice weekly
Gamma Scan	Samples showing greater than 1 pCi/m^3 of gross beta
Plutonium-238, Plutonium-239, Plutonium-240, Uranium-234, Uranium-235, Uranium-238	Annually on a composite of the filters from each station

Results and Discussion

As can be seen in Figure 2, the results for the gross beta analysis were very similar for each monitoring station in the ERAMS program, and nearly all were lower than the concentrations at the perimeter background station located near Fort Loudoun Dam in Loudon County at corresponding times. While it is not uncommon for concentrations to be lower on the ORR than at the background stations, data reported for the ERAMS stations has consistently been lower than the data reported for the Fugitive and Perimeter Monitoring Programs. This slight bias is believed to be an artifact of the different equipment and monitoring frequency used in the programs and can also be seen in Figure 3. The fluctuations in the results at all of the sites presented in Figure 2 are largely attributable to natural phenomena (e.g., wind and rain) that influence the amount of particulates suspended in the air and thus what is ultimately deposited on the filters.

As was noted in the data for the Perimeter Air Monitoring Program, the results for the ERAMS program were higher overall for the two stations immediately adjacent to the Y-12 National Security Complex (i.e., stations Y-12 East and Y-12 West). It is probable the higher results are associated with Y-12's campaign to modernize operational facilities and tear down unneeded buildings, but the exact cause is unknown.

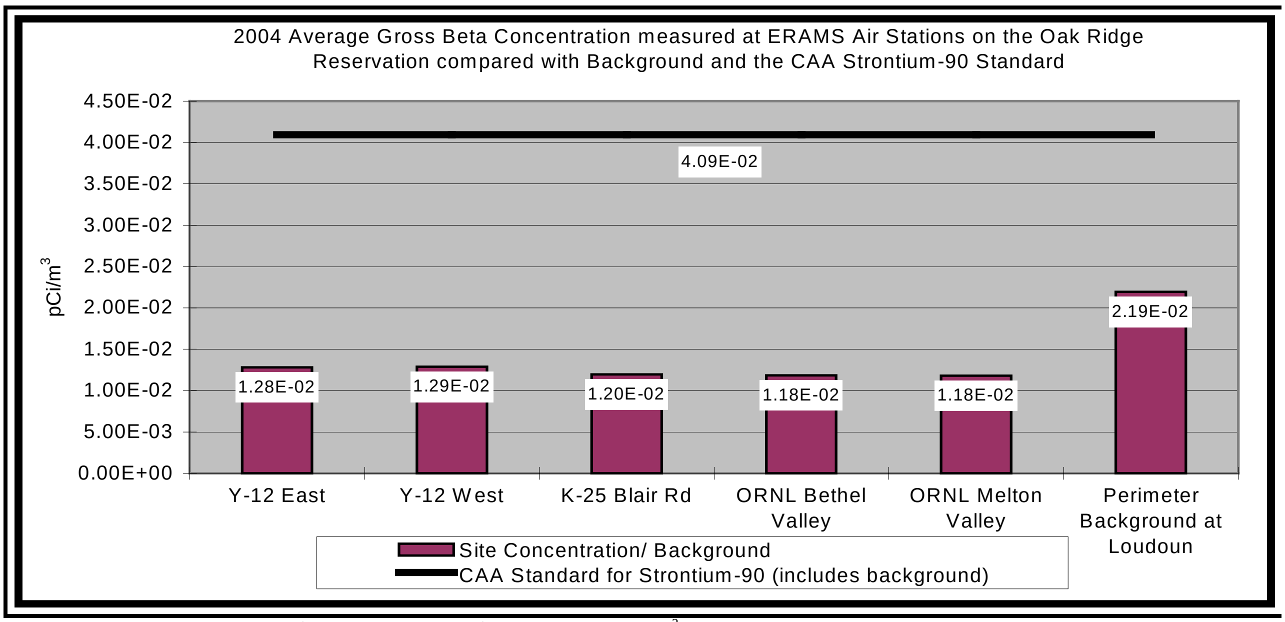


Note: Typical background values for gross beta range from 0.005 - 0.1 pCi/m^3 (ORISE, 1993)

Figure 2: 2004 Gross Beta Results from Air Samples taken on the ORR in Association with EPA's Environmental Radiation Ambient Monitoring System and Background from the Division's Perimeter Air Monitoring Program

The chart in Figure 3 depicts the 2004 average gross beta results for each station in the ORR ERAMS Program, along with the average background from the Perimeter Air Monitoring Program site at Fort Loudoun Dam and compares them all to the Clean Air Act (CAA) environmental limit for strontium-90. The CAA specifies that exposures to the public from radioactive materials released to the air from DOE facilities shall not cause members of the public to receive an effective dose equivalent greater than 10 mrem in a year. The CAA specifies environmental concentrations for specific radionuclides that would be equivalent to this dose limit, but does not provide a standard for gross measurements. To evaluate the ERAMS data, staff compare the gross beta results reported for the program to the CAA limit for strontium-90, which has one of the most stringent standards of the beta emitting radionuclides. The standards apply to the dose above background, so the limit represented in Figure 3 has been adjusted to include the average gross beta measurement taken at the background station for the Perimeter Air Monitoring Program. It should be understood that strontium-90 is unlikely to be a large contributor to the total beta measurements reported here and is used only as a reference point to determine if further analysis is justified.

As can be seen in Figure 3, the average results for the Y-12 East and Y-12 West monitoring stations are slightly higher than the remaining stations, but each of the ERAMS monitoring stations fall well below strontium-90 limit.



Note: Typical Background values for gross beta range from 0.005- 0.1 pCi/m^3 (ORISE, 1993)

-The standards provided by the Clean Air Act apply to the dose above background; therefore, the standard provided for reference in this figure has been adjusted to include the background measurements taken from the division's Perimeter Air Monitoring Program during the same period.

- The CAA's Environmental Limit for strontium-90 is used as a screening mechanism and is provided here for comparison. It is unlikely the isotope contributes a major proportion of the gross activity reported for the samples.

Figure 3: 2004 Average Gross Beta Results for Air Samples taken on the ORR in Association with EPA's Environmental Radiation Ambient Monitoring System

Conclusion

As in the past, the gross beta results for each of the five ERAMS air monitoring stations exhibited similar trends and concentrations. While slightly higher results were reported at monitoring locations near the Y-12 National Security Complex, the available ERAMS data for 2004 do not indicate a significant impact on the environment or public health from ORR emissions.

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CHAPTER 1 AIR QUALITY MONITORING

Fugitive Radiological Air Emissions Monitoring (RMO)

Principal Authors: Natalie Pheasant, Howard Crabtree

Abstract

The Tennessee Department of Environment and Conservation uses high volume air samplers to monitor radioactive contaminants in fugitive air emissions released on the Oak Ridge Reservation. From August of 1999 through 2004, one of the monitors was stationed between the K-31 and K-33 Process Buildings at the East Tennessee Technology Park. These facilities and associated equipment served in the production of enriched uranium and were significantly contaminated as a consequence of process operations. During the monitoring time frame, equipment in the buildings was removed and the facilities decontaminated. Results from monitoring these activities ranged from background levels up to five times the background levels, but the annual average concentrations appear to have remained below Clean Air Act Standards (10 mrem/yr).

Introduction

The Tennessee Department of Environment and Conservation's Department of Energy Oversight Division conducts monitoring for fugitive radiological air emissions on and in the vicinity of the Oak Ridge Reservation (ORR). This program uses a portable high volume air monitor to supplement air sampling performed at fixed locations. In addition to its mobility, the high volume monitors provide greater measurement sensitivity and resolution than can be achieved with the low volume monitors used in the division's Perimeter Air Monitoring Program.

From August 1999 through December 2004, the portable sampler has been used to monitor emissions from the K-31 and K-33 Process Buildings (K31/33) at the East Tennessee Technology Park (ETTP). Together, these facilities cover more than 47 acres of land and contain greater than 150 acres of floor area. During operations, the facilities were an integral part of the uranium enrichment process and are known to be contaminated with uranium isotopes, technetium-99, and transuranic radionuclides. Both facilities were cleaned up under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

Methods and Materials

Two high volume air samplers are used in this program. One of these units is mobile, allowing it to be moved to different locations of interest. The second unit has been stationed at Fort Loudoun Dam in Loudon County to collect background information. Both samplers use 8x10 glass fiber filters to collect particulate matter in air pulled through the units. The filters are collected weekly by staff and shipped by certified mail to the Tennessee Department of Public Health Radiochemistry Laboratory for analysis. Analysis includes gross alpha, gross beta, and gamma spectrometry on each of the weekly samples, with additional analysis performed where merited.

Monitoring in this program is directed toward locations where there is a potential for the release of fugitive/diffuse air emissions as a consequence of remedial or waste management activities. Results from the portable sampler are compared to background data collected by the monitor placed at Fort Loudoun Dam and environmental standards provided for radionuclides in 40CFR61 Appendix E Table 2 of the Clean Air Act (CAA).

Results and Discussion

As previously noted, the portable monitor has been stationed between the K-31 and K-33 Process Buildings at ETTP, since August 1999. These facilities, along with associated equipment, were contaminated during process operations and are currently being remediated in association with a CERCLA Action Memorandum issued in 1997 (DOE, 1997). The primary contaminants are uranium isotopes: although, technetium-99 and transuranic radionuclides are also present due to the processing of spent nuclear fuel. While individual results have fluctuated over the years, a general trend can be observed in the data that has consistently risen from background levels to greater than five times the results reported at the background station. To illustrate this trend, Figure 1 depicts gross alpha data reported for the K31/33 facilities minus background measurements from August 1999 through December 2004. Negative values in the chart represent instances where the background measurements exceeded the field measurements, which is not uncommon on the reservation (in the absence of man-made influences). Decreased concentrations that can be noted in 2002 and 2004 occurred after the escalating results were brought to the attention of the contractor over the project.

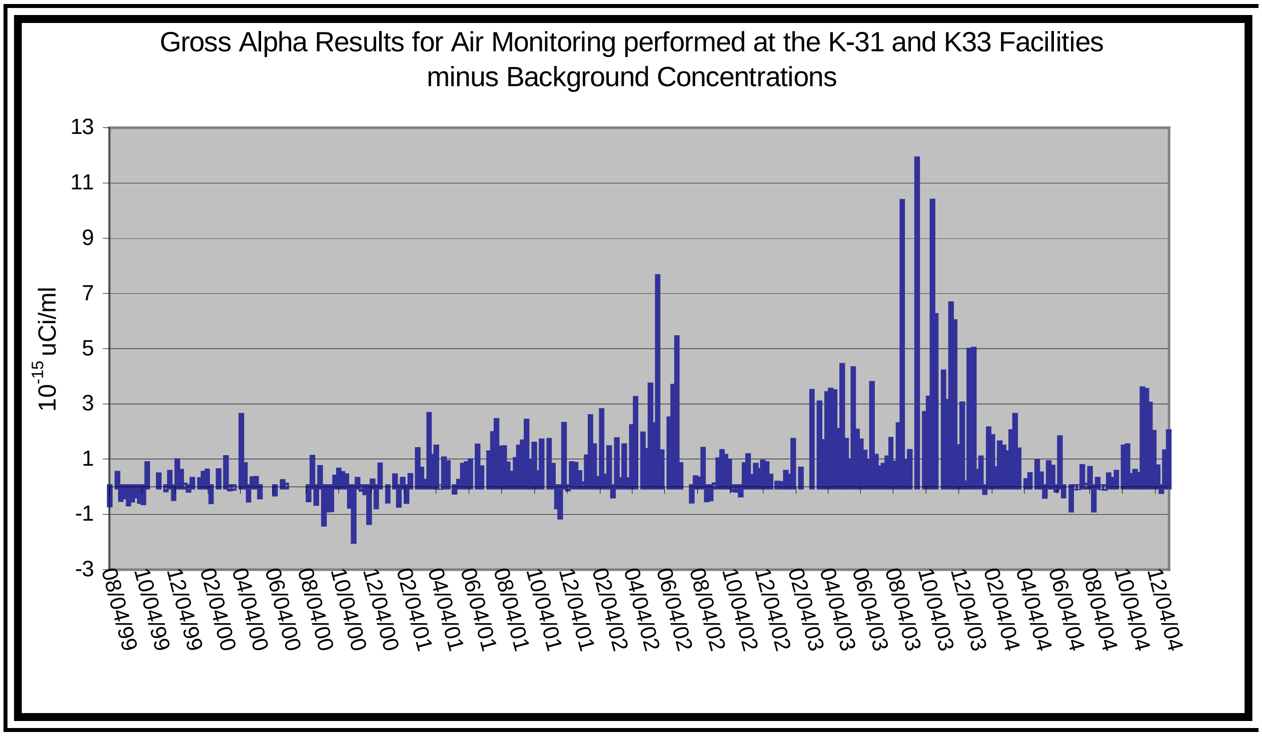


Figure 1: Gross Alpha Activities reported for Monitoring performed at the K-31 and K-33 Process Buildings minus Background Concentrations from Fort Loudoun Dam (08/04/99 to 12/29/04)

For this project, the results from the air sampler at the K-31/33 facilities were compared to background data to determine if releases were occurring. The data was then compared to CAA environmental standards to assess if any releases identified were likely to have exceeded the 10 mrem/year standard. In either case, both state and federal regulations require radioactive emissions to be as low as reasonably achievable (ALARA).

K-31/33 Results vs. Background Data

Figures 2 and 3 compare gross alpha and beta results from the K-31/33 facilities to background data taken at Fort Loudoun Dam during the same time period. As can be noted in the figures:

- Initial results from samples taken at the K-31/33 facilities were consistent with measurements and trends observed at the background station.
- In 2001, the alpha results increased slightly, but continued to follow the short-term trends seen in the background data.
- In the spring of 2002, the K-31/33 results diverged from the trends observed at the background station (i.e., the ETTP values increased, where background data decreased), indicating an increase of emissions from the ETTP Process Facilities or an additional contribution to the levels measured from a new and unknown source.
- In the winter of 2002, the results declined to near background levels after discussions with DOE's contractor on the project. The elevated results were reported to be attributable to accelerated activities in the K-31 facility.
- In the spring of 2003, the results began to climb from background levels to the highest measurements reported at the site. In contrast to previous years, the gross beta measurements climbed significantly, along with the concentrations of gross alpha. After being notified of the escalating results, the DOE contractor for the project advised that the elevated results were believed to be a consequence of work being performed in the K-31 Building near the division's monitor.
- In November and December 2003, the results at K-31/33 abruptly dropped and remained relatively consistent with background measurements through 2004.

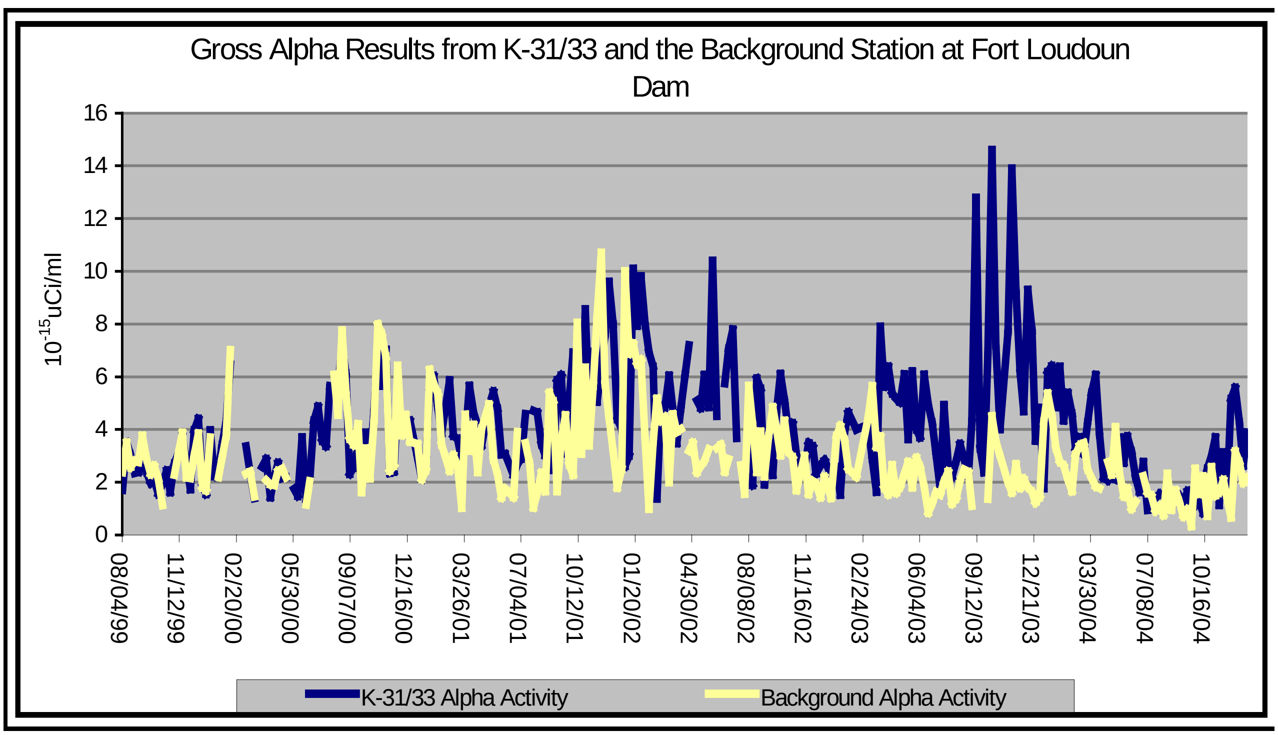


Figure 2: Gross Alpha Results from Fugitive Air Monitoring Performed at the K-31 and K-33 Facilities and the Background Station at Fort Loudoun Dam from 08/04/99 to 12/29/04

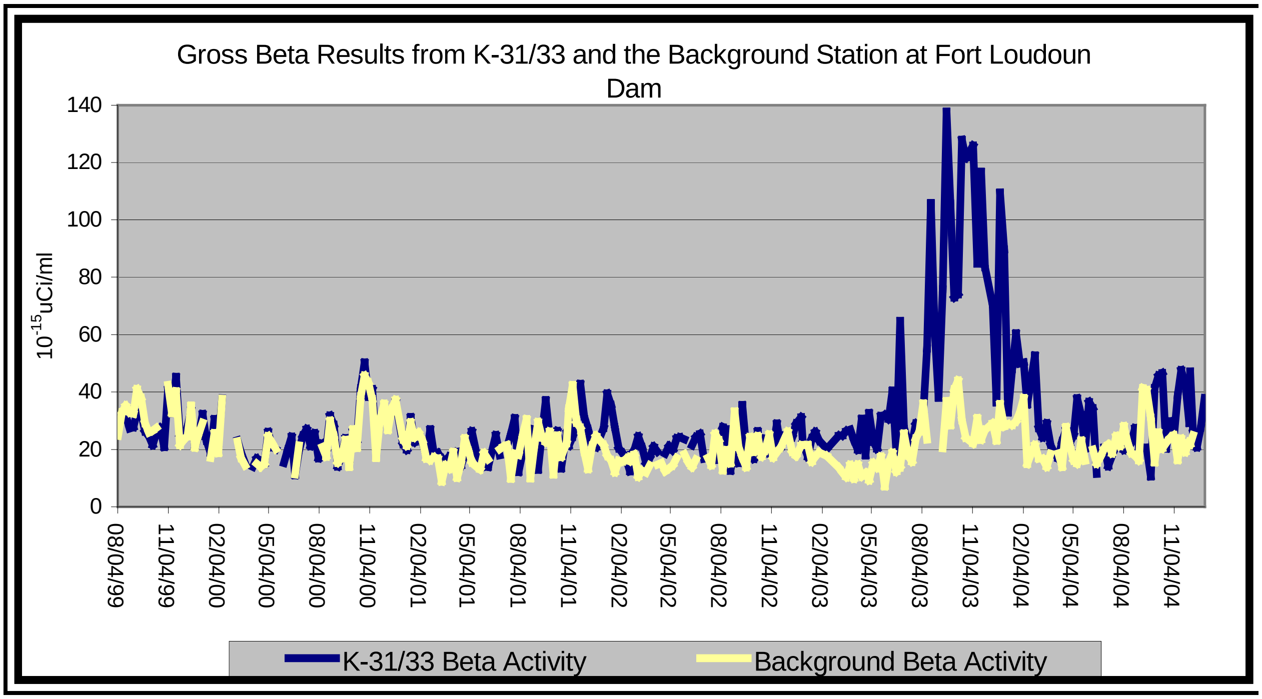


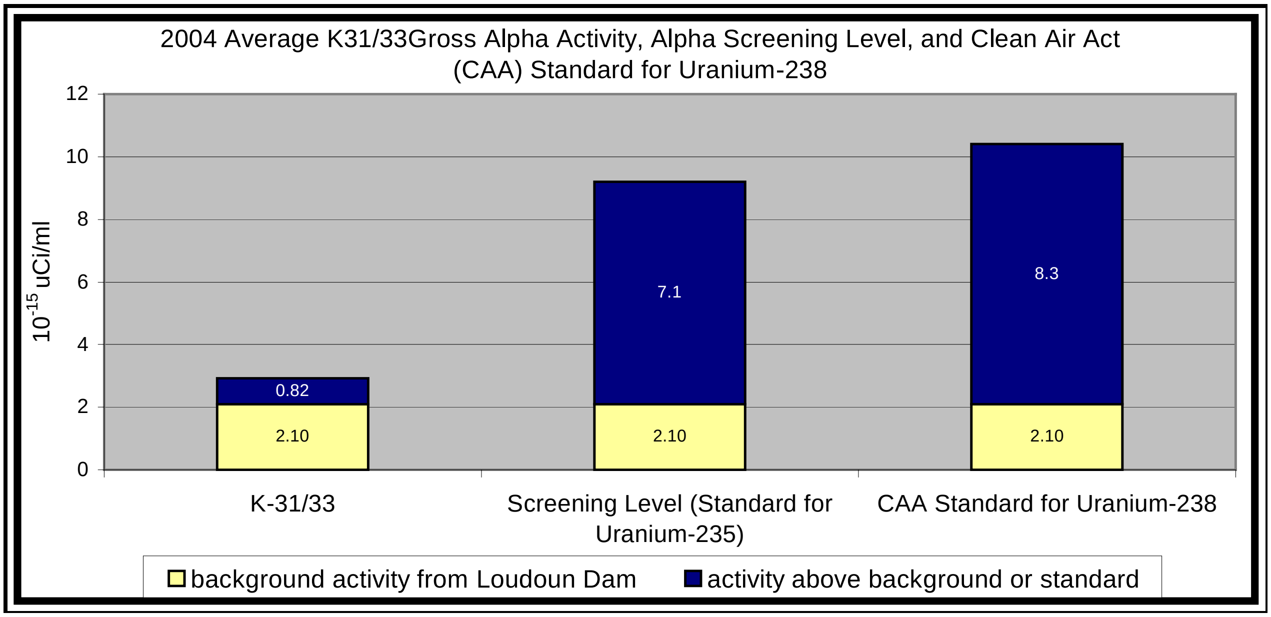
Figure 3: Gross Beta Results for Monitoring Performed at the K-31 and K-33 Facilities and the Background Station at Fort Loudoun Dam, Loudon County from 08/04/99 to 12/29/04

K-31/33 Results vs. CAA Standards

The CAA specifies that exposures to the public from radioactive materials released to the air from DOE facilities shall not cause members of the public to receive an effective dose equivalent greater than 10 mrem in a year. Compliance with this standard is generally determined for point source emissions that employ air dispersion models to predict the dose at off-site locations. However, the CAA also provides environmental concentrations for radionuclides that can be used to demonstrate compliance with the 10 mrem/year limit. TDEC staff use these standards to evaluate the predictions derived from the air dispersion models and to assess fugitive emissions.

Because the hazards associated with the various radionuclides differ significantly, the CAA requires specific analysis for each isotope determined to be of concern. Consequently, the standards provided by the CAA do not include limits for gross alpha and beta activities. Nevertheless, the more economical gross measurements, when treated as surrogates for the more hazardous isotopes, provide an effective screening mechanism to determine if further evaluation is warranted. The standards used in the program to screen the data are those of uranium-235 (primarily an alpha emitter) and strontium-90 (a beta emitter). Both have relatively restrictive limits and both are routinely encountered on the reservation.

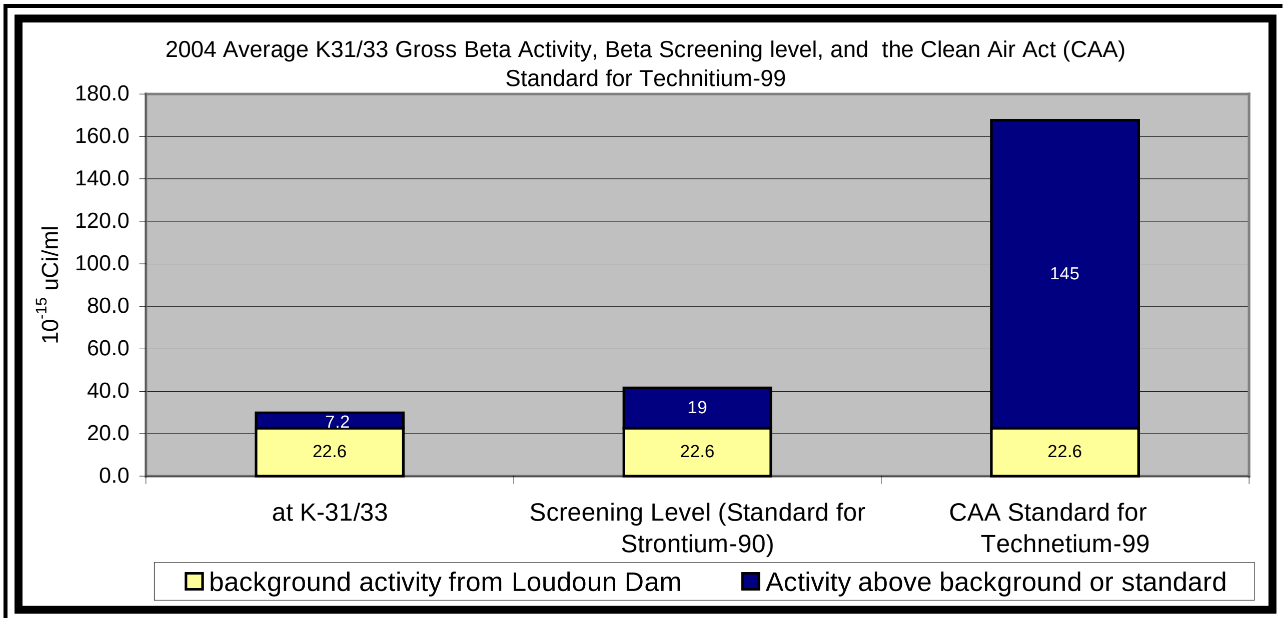
The 2004 average gross alpha and beta activities at the K-31/33 facilities and the background station are provided in Figures 4 and 5. The predominant contributors to the gross results are expected to be uranium-238 (from depleted uranium) and technetium-99 (a contaminant derived from recycling spent fuel). The CAA standards for both have been included in Figures 4 and 5. Since the environmental limits provided by the CAA apply to the dose above background, the standards depicted in the Figures 4 and 5 have been adjusted to include the average background measurement for 2004.



Note: -The standards provided by the Clean Air Act apply to the dose above background; therefore, the standards provided for reference in this figure have been adjusted to include background measurements taken during the same period.

-The CAA's Environmental Limit for uranium-235 is used as a screening mechanism and is provided here for comparison. It is unlikely the isotope contributes a major proportion of the gross activity reported for the samples.

Figure 4: Average Gross Alpha Measured at the K-31 and K-33 Process Buildings During 2004 Compared to Background Measurements, the Alpha Screening Level, and the CAA Standard for Uranium-238



Note: -The standards provided by the Clean Air Act apply to the dose above background; therefore, the standards provided for reference in this figure have been adjusted to include background measurements taken during the same period.

-The CAA's Environmental Limit for strontium-90 is used as a screening mechanism and is provided here for comparison. It is unlikely the isotope contributes a major proportion of the gross activity reported for the samples.

Figure 5: Average Gross Beta Measured at the K-31 and K-33 Process Buildings during 2004 Compared to Background Measurements, the Beta Screening Level, and the CAA Standard for Technitium-99

Conclusion

From 1999 through 2003, results from fugitive air monitoring at the K-31 and K-33 facilities fluctuated but trended upward from near background levels to measurements five times the background levels. In late 2003, the results for the site dropped abruptly after discussions of the rising concentrations with the contractor in charge of the clean up of the facilities, suggesting the cause of the elevated results had been identified and mitigated. In 2004, the concentrations measured at the facilities were relatively consistent with background results.

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CHAPTER 1 AIR QUALITY MONITORING

Oak Ridge Reservation Perimeter Ambient Air Monitoring Program (RMO)

Principal Authors: Howard Crabtree, Natalie Pheasant, James L. Dunlap

Abstract

The Tennessee Department of Environment and Conservation conducts a perimeter air monitoring program on the Oak Ridge Reservation using low volume air samplers. This program, in conjunction with associated air monitoring programs, provides information used to assess the impact of Department of Energy activities on the local environment and public health. In the program, samples are collected biweekly from twelve air monitors stationed near the boundaries of the reservation and at a background location (i.e., Fort Loudoun Dam). Each sample is analyzed for gross alpha and gross beta radiation at the state radiochemistry laboratory. A composite sample from each location is analyzed annually for gamma emitters. Results from the perimeter monitoring stations are compared to the background measurements and environmental standards provided in the Clean Air Act. The data for 2004 did not indicate a significant impact on local air quality from activities on the reservation.

Introduction

The Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division provides radiochemical analysis of air samples taken from twelve low volume air monitors located on and in the vicinity of the Oak Ridge Reservation (ORR). The monitors used to collect the samples are owned by DOE and maintained by DOE contractors. Data derived from this program, along with information generated by the other air monitoring programs on the reservation, are used to:

- Assess the impact of DOE activities on the public health and environment,
- Identify and characterize unplanned releases,
- Establish trends in air quality, and
- Verify data generated by DOE and its contractors

Methods and Materials

The twelve air monitors used in the program are owned by DOE and DOE contractors are responsible for their maintenance and calibration. Nine of the units are a component of DOE's ORR perimeter air monitoring system. The remaining three monitors were previously used by the Y-12 complex in their perimeter air monitoring program.

Each of the monitors use forty-seven millimeter borosilicate glass fiber filters to collect particulates in the air pulled through the units. The ORR perimeter monitors employ a pump and flow controller to maintain airflow through the filters at approximately two standard cubic feet per minute. The Y-12 monitors use a pump and rotometer, which are set to average approximately two standard cubic feet per minute.

Air filters from the monitors are collected biweekly and sent by certified mail to the state's radiochemical laboratory in Nashville, Tennessee, for analysis. Analysis includes gross alpha and gross beta on the biweekly samples. Gamma spectrometry is performed on samples that exhibit elevated gross alpha or beta results and annually on composite samples.

The twelve air monitoring stations used in the program are listed in Table 1. Eleven of these stations are located around the perimeter of the ORR and Y-12 facility (Figure 1). The twelfth site is the background station located near Fort Loudoun Dam in Loudon County.

Table 1: Perimeter Air Monitoring Stations

Station	Location	County
4	Y-12 Perimeter near portal 2	Anderson
5	Y-12 Perimeter near Building 9212	Anderson
8	Y-12 Perimeter west end near portal 17	Anderson
35	East Tennessee Technology Park	Roane
37	Bear Creek at Y-12 / Pine Ridge	Roane
38	Westwood Community	Roane
39	Cesium Fields at Oak Ridge National Laboratory	Roane
40	Y-12 East	Anderson
42	East Tennessee Technology Park off Blair Road	Roane
46	Scarboro Community	Anderson
48	Deer Check Station on Bethel Valley Road	Anderson
52	Fort Loudoun Dam (Background Station)	Loudon

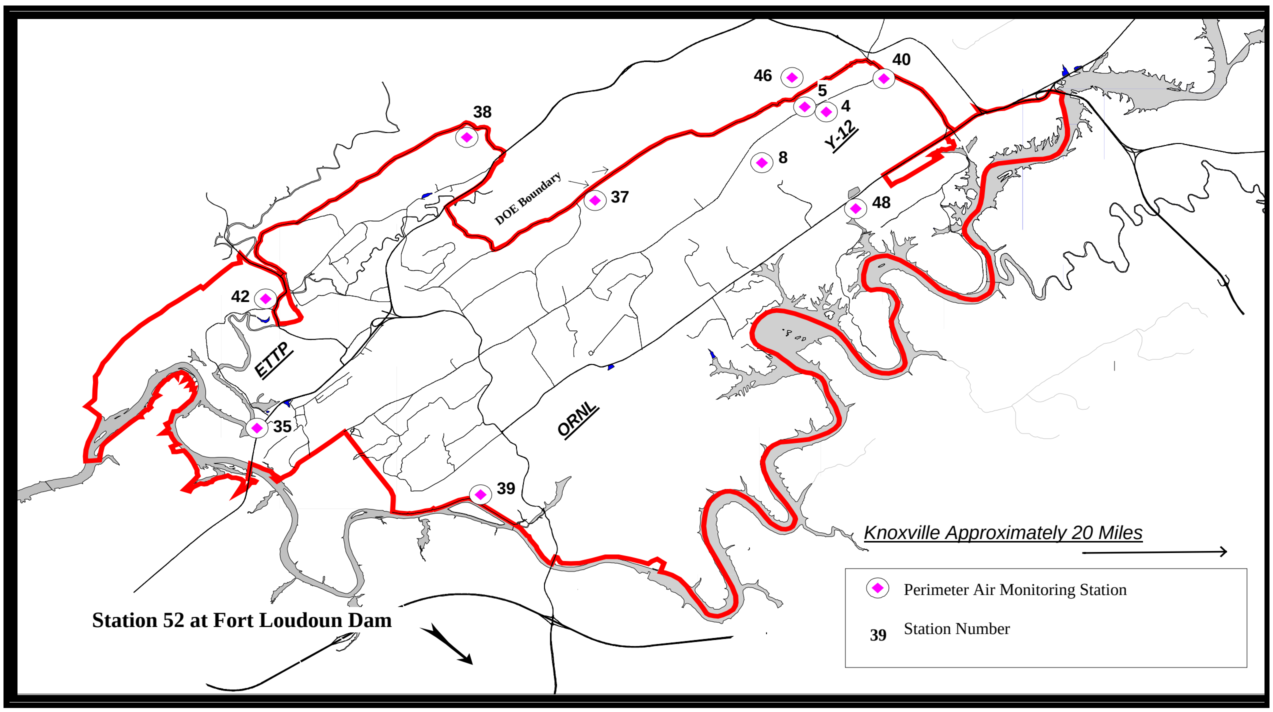


Figure 1: Approximate Location of Perimeter Air Monitoring Stations

Results and Discussion

In general, results reported in 2004 for the perimeter air monitoring stations were near those reported for the background station. Similar trends in the activities for gross alpha and gross beta were observed for each monitoring station. Figures 2 and 3 illustrate the correlation between fluctuations in the gross alpha and beta results at the perimeter stations and the background location. These fluctuations, to a large degree, can be attributed to natural phenomena or changing environmental conditions, which increase or decrease the amount of particulate deposited on the sampling filters. For example, concentrations of potassium-40 and radionuclides in the uranium and thorium decay series may increase, because soils in which they naturally occur have been dispersed in the air as a consequence of dry conditions, heavy winds, and/or local activities (e.g., construction). Conversely, rain and snow can remove materials suspended in the air reducing the concentration of contaminants deposited on the air filters.

Figures 2 and 3 depict the results for each of the perimeter monitoring stations and the background station during 2004. As in 2002 and 2003, stations in the vicinity of the Y-12 National Security Complex had slightly higher concentrations over all, which could be due to the current campaign at the facility to modernize operational facilities and tear down unneeded buildings. Anomalous results that can be observed in the figures for samples collected from Station 38 on 01/27/04 and 02/10/04 were not reflected in the other results and are believed to be due to sampling error.

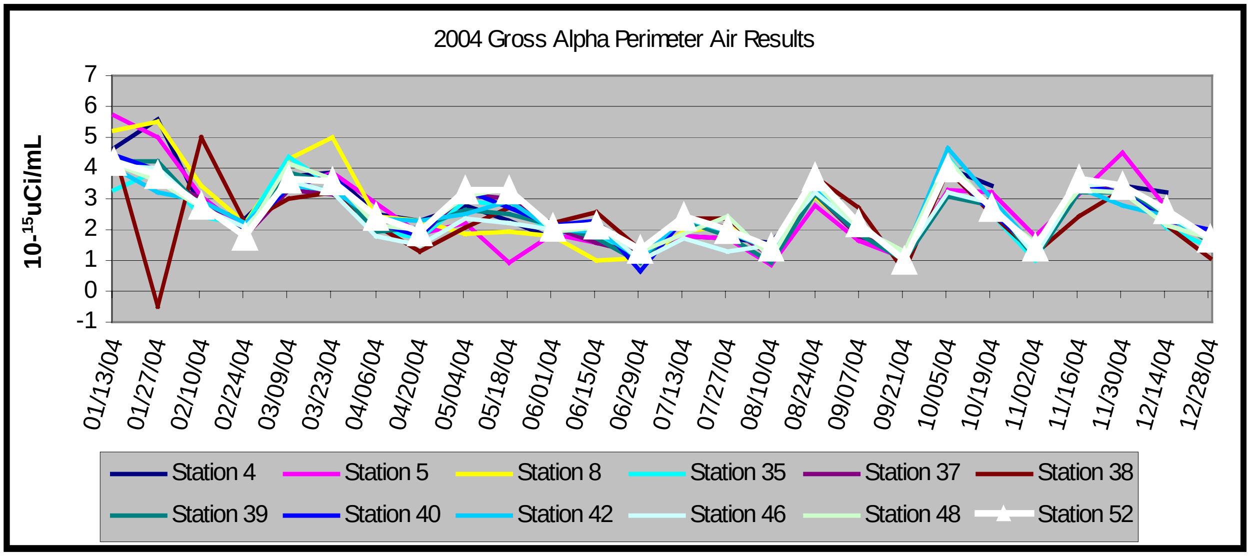


Figure 2: 2004 Gross Alpha Results for TDEC Perimeter Air Monitoring Stations on the ORR

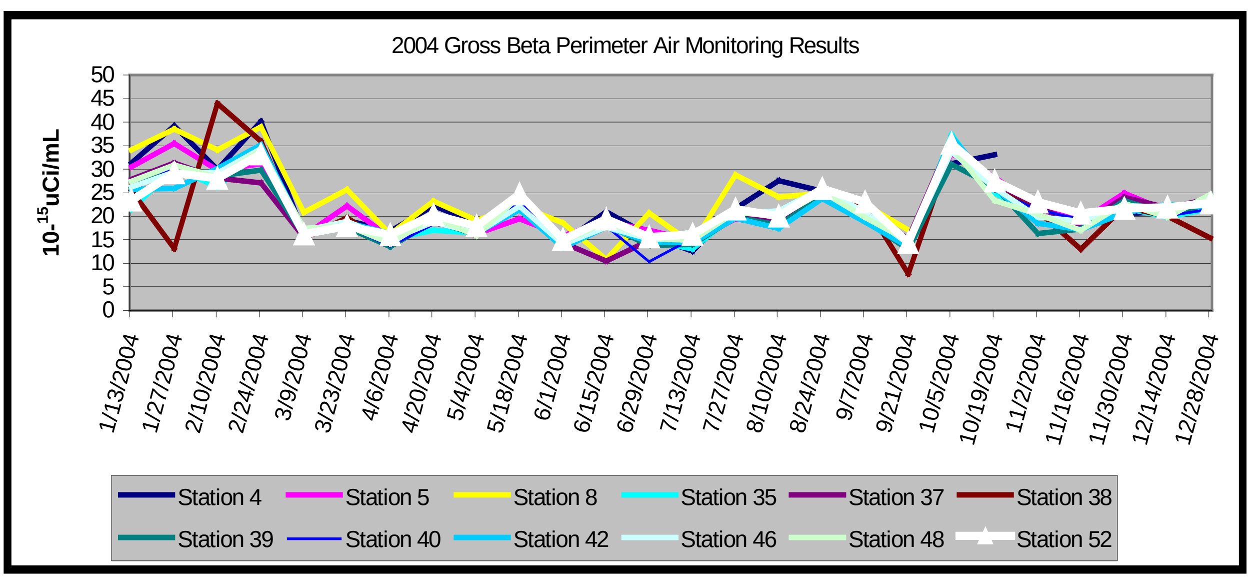
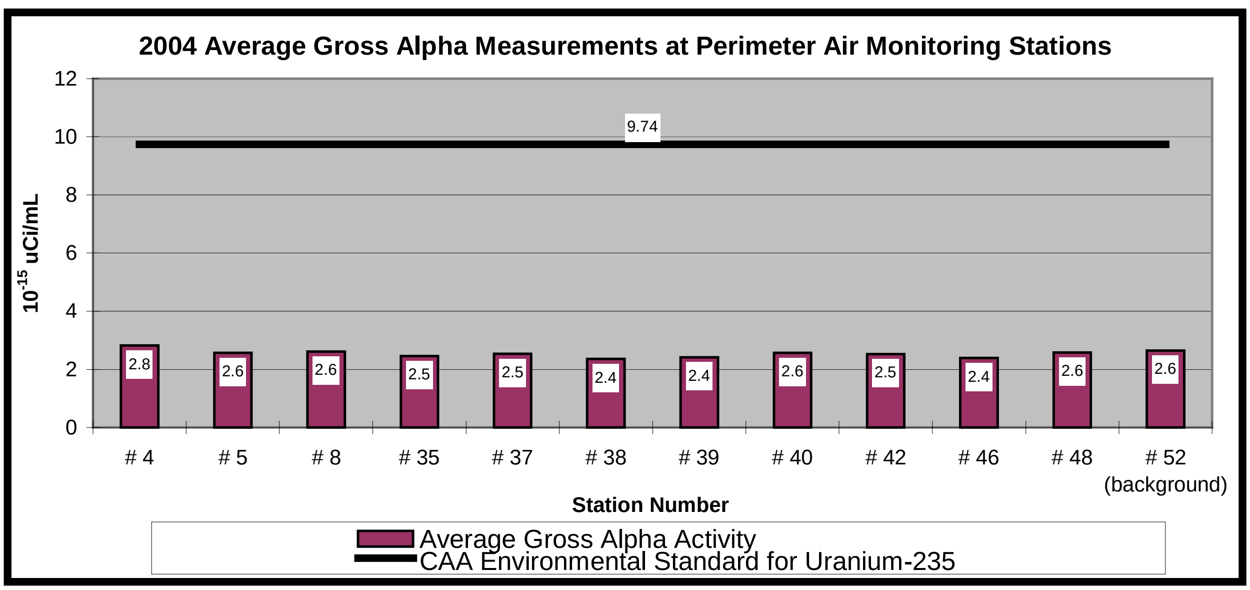


Figure 3: 2004 Gross Beta Results for TDEC Perimeter Air Monitoring Stations on the ORR

The simplest method of assessing the impact of ORR air emissions on the local environment is to compare results from the perimeter monitoring stations to those of the background station located at Fort Loudoun Dam (Station 52). As can be seen in Figures 2 through 5, the activities reported for the perimeter air monitoring stations for gross alpha and gross beta were relatively consistent with the background values, with the exceptions previously noted at the Y-12 National Security Complex.

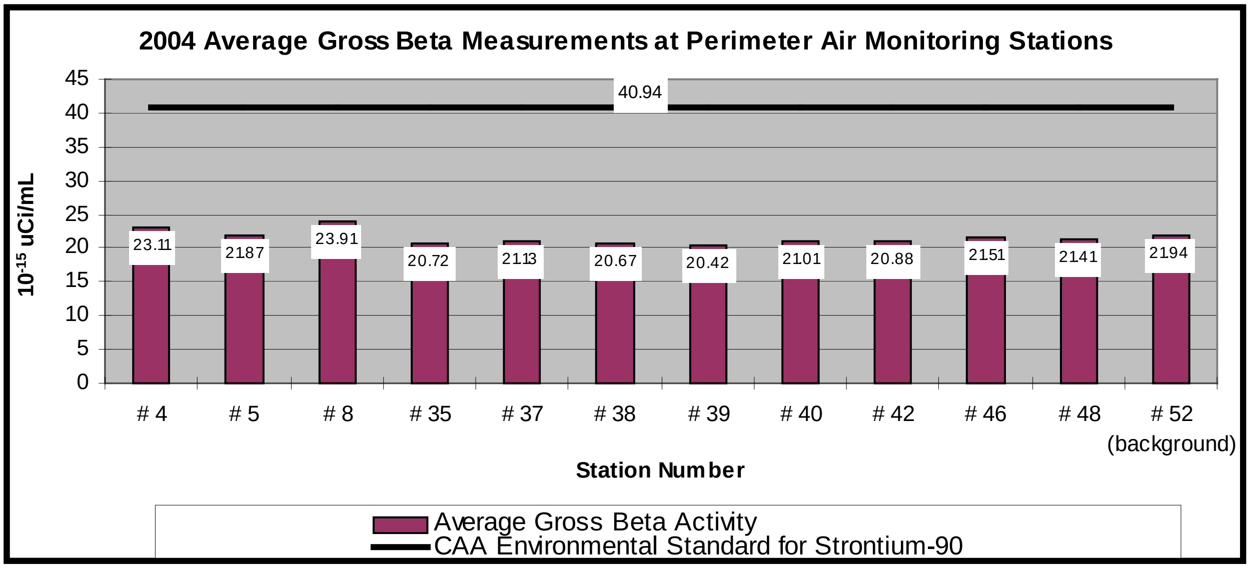
The Clean Air Act (CAA) specifies that exposures to the public from radioactive materials released to the atmosphere from DOE facilities shall not cause members of the public to receive, in a year, an effective dose equivalent greater than 10 mrem above background measurements. Data from TDEC's air monitoring is compared to ambient air concentrations provided in the CAA for demonstrating compliance with the 10 mrem/year limit. While the CAA environmental standards do not include limits for gross alpha and beta, these measurements provide an effective tool to assess if further analysis is merited.

Figures 4 and 5 show the average activity for gross alpha and beta measured during the year 2004 at the perimeter air stations. The CAA environmental standards (adjusted to include background radiation) for uranium-235 (primarily an alpha emitter) and strontium-90 (a beta emitter) are provided for comparison. These isotopes have some of the more restrictive standards prescribed by the CAA. It should be understood that it is very unlikely that these isotopes would be responsible for a major proportion of the gross activity reported for the samples.



*The standards provided by the Clean Air Act apply to the dose above background: therefore, the standard provided for reference in the figure has been adjusted to include the background measurements.
**The CAA's Environmental limit for uranium-235 is provided for comparison. It is unlikely the isotope contributes a major proportion of the gross activity reported for the samples.

Figure 4: 2004 Average Gross Alpha Results for TDEC Perimeter Air Monitoring Stations on the ORR



*****The standards provided by the Clean Air Act apply to the dose above background: therefore, the standard provided for reference in the figure has been adjusted to include the background measurement.

**The CAA's Environmental Limit for strontium-90 is provided for comparison. It is unlikely the isotope contributes a major proportion of the gross activity reported for the samples.

Figure 5: 2004 Average Gross Beta Results for TDEC Perimeter Air Monitoring Stations on the ORR

The annual gamma analysis performed on composite samples from each station has not been completed; consequently, these results were not available for this report. In the past, the gamma results have been considered consistent with background measurements.

Conclusion

Environmental concentrations of radionuclides in the atmosphere tend to vary from location to location and seasonally in response to natural and anthropogenic influences. In this regard, results of radiochemical analysis of samples taken at ORR perimeter air monitoring stations appear to follow similar trends as the background station located near Fort Loudoun Dam. In general, concentrations of radionuclides reported for the perimeter air monitoring stations were consistent with data reported for the background stations. Stations in the vicinity of the Y-12 National Security Complex had slightly higher concentrations over all, which could be due to the current campaign at the facility to modernize operational facilities and tear down unneeded buildings. All results were within CAA standards.

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CHAPTER 2 BIOLOGICAL/FISH AND WILDLIFE

Fish Tissue Monitoring

Principal Author: Roger Petrie

Abstract
The Tennessee Valley Authority (TVA) conducts an annual Black Bass Survey to evaluate the condition of the reservoirs in the Tennessee River Valley. The DOE Oversight Division attempted to acquire largemouth bass from TVA at locations around the ORR during the annual Black Bass Survey in order to compare results with those from other agencies and organizations. Due to seasonal conditions, an insufficient number of specimens of adequate size were not obtainable. Therefore this project was not completed in 2004. Subsequent meetings with TVA, TWRA, and ORNL staff resulted in a new plan for 2005.

Introduction
The Tennessee Department of Environment and Conservation posts warning signs on streams or lakes in which public health is endangered. In Tennessee, the most common reasons for a river or lake to be posted are the presence of sewage bacteria or other contaminants in the water, sediment, or fish of a waterbody.

When fish tissue samples show levels of a contaminant higher than established criteria, the waterbody is posted and the public is advised of the danger. If needed, TWRA can enforce a fishing ban. Approximately 84,100 lake acres and 142 river miles across the state are currently posted due to contaminated fish. When the department issues new advisories, signs are placed at significant public access points and a press release is submitted to local newspapers.

The State of Tennessee posts two types of advisories. A public fishing advisory will be considered when the calculated risk of additional cancers 10^{-4} for typical consumers 10^{-5} for atypical consumers. A "do not consume" advisory will be issued for the protection of typical consumers and a "precautionary advisory" will be issued for the protection of atypical consumers.

The Tennessee Valley Authority (TVA) conducts an annual Black Bass Survey to evaluate the condition of the reservoirs in the Tennessee River Valley. The DOE Oversight Division attempted to acquire five largemouth bass from TVA during the survey conducted on Melton Hill Reservoir in order to compare results with those from other agencies and organizations.

Methods and Materials
Black bass were collected using electrofishing boats. Specimens of at least one pound were needed for analysis. Only two fish over one pound were collected. Since this was not an adequate sample size, it was decided not to keep these fish.

Results and Discussion

Since insufficient numbers of specimens of adequate size were collected, no analysis was conducted.

Conclusion

Based on discussions at the annual Fish Tissue Meeting, it was decided to continue sampling in 2005. This sampling is covered under the 2005 Fish Tissue Monitoring Environmental Monitoring Plan.

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Chapter 2 BIOLOGICAL/FISH AND WILDLIFE

Canada Geese Monitoring

Principal Author: Roger Petrie

Abstract

On June 24 and 25, 2004, the Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division (DOE-O) conducted oversight of the annual Canada Geese (Branta canadensis) monitoring project on the Oak Ridge Reservation (ORR). The objective of this study was to determine if geese are becoming contaminated on the ORR. The captured geese were transported to the Tennessee Wildlife Resources Association (TWRA) game check station on Bethel Valley Road and tested for radioactive contamination. None of the geese captured at this year showed elevated gamma counts above the 5pCi/g game release level. Since no contaminated geese were captured, the DOE-Oversight Division did not conduct additional offsite sampling of Canada Geese.

Introduction

A large population of Canada geese, both resident and transient, frequents the Oak Ridge Reservation (ORR) (Crabtree 1998). The thriving goose population in this area makes this animal an easily accessible food for area residents. Geese with elevated levels of Cs137 in muscle tissue have been found on the ORR (MMES 1987 and Loar 1994). Studies in the 1980s demonstrated that geese associated with the contaminated ponds/lakes on the ORR can accumulate radioactive contaminants quickly and that contaminated geese frequent off site locations (Loar 1990, Waters 1990, MMES 1987).

Every year the Department of Energy (DOE) and Tennessee Wildlife Resource Agency (TWRA) capture geese on the ORR during the annual “Goose Roundup” and perform whole body counts on them to determine if the birds are radioactively contaminated. During the 1998 “Goose Roundup,” 38 geese at ORNL contained Cesium 137 concentrations that exceeded the game release limit of 5 pCi/g (ORNL 1998). A subsequent study in September 1998 found elevated levels of Cs137 in grass and sediment at two reaches of White Oak Creek south of 3513 Pond and in grass around the 3524 pond (ORNL 1998). In 2002, three young of the year geese from the west end of ORNL were found to have Cesium 137 levels above the game release level. In 2003, no geese were found to have Cesium 137 levels above the game release level.

The Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division (DOE-O) has a sampling plan that is implemented when geese with elevated gamma readings are detected during the regular “Goose Roundup.” If any geese with elevated gamma readings are detected, then arrangements are made to sample geese that are found in the vicinity of the ORR on non-DOE property. This is to determine if contaminated geese are leaving the reservation and are presenting a risk to area hunters.

Results and Discussion

During the 2004 sampling, a total of 297 birds were captured. Most of the adult geese were banded and all were released. A subsample of twenty birds from each site were given total body counts for five minutes with a sodium iodide detector at the TWRA game checking facility on Bethel Valley

Road. None of the birds analyzed had levels of gamma above the 5pCi/g game release level. In fact, none of the analyzed birds had levels of Cesium 137 above 0.3 pCi/g. Table 1 shows results of the 2004 DOE Goose Roundup.

Table 1.
2004 DOE Goose Round-up Results

Site	Date	# Captured	Adults	Juveniles	# > 5pCi/g
ETTP (K-1007 Area)	6/24	127	127	0	0
ETTP (CNF Area)	6/24	17	8	9	0
ORNL (STP Area)	6/24	20	14	6	0
ORNL (1505 Area)	6/24	16	5	11	0
Clark Center Park	6/25	117	94	23	0
Totals		297	248	49	0

Since none of the birds analyzed showed signs of contamination, no additional offsite sampling was conducted.

Conclusion

Although none of the birds analyzed showed signs of contamination, historical information indicates that this species is still susceptible to contamination from sources on the ORR. It does, however, indicate that there is a reduced likelihood of this situation existing.

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CHAPTER 2 BIOLOGICAL/FISH AND WILDLIFE

Benthic Macroinvertebrate Biomonitoring Using a Semi-Quantitative Approach: Rapid Bioassessment Protocol (RBP III)

Principal Author: Randy Hoffmeister

Abstract

Semi-quantitative benthic macroinvertebrate samples were collected from study sites on four streams impacted by Department of Energy (DOE) operations. Using the State of Tennessee standard operating procedures for macroinvertebrate surveys, samples were collected, processed, and analyzed using applicable metrics. A score was calculated from the metrics and a stream site health rating was assigned. In general, results showed signs of biotic improvement with distance from DOE influences. Only two study sites had a stream rating as healthy as Bioregion reference conditions. Continued benthic macroinvertebrate monitoring would more closely define impacts on the aquatic environment from DOE related activities. Assessments of DOE remedial activities and cleanup efforts can also be made from generated data.

Introduction

Benthic macroinvertebrates are organisms that inhabit the bottom substrates of aquatic systems. Examples include insects, crustaceans, annelids, and mollusks. Because of their relatively long life spans and sedentary nature, benthic macroinvertebrate community structure can be useful in assessing the condition or health of an aquatic system. A continuous biomonitoring program is a proven method of assessing and documenting any changes that may occur within the impacted system.

Benthic macroinvertebrate and surface water samples were collected from locations on four streams originating on the ORR that have been impacted by past and present DOE operations. Two of these streams, East Fork Poplar Creek and Bear Creek, have been impacted by the Y-12 Plant. The East Tennessee Technology Park (ETTP) has impacted Mitchell Branch. White Oak Creek has been impacted by operations at the Oak Ridge National Laboratory (ORNL). The objective of this study was to assess and document the health of ORR streams compared to ideal reference conditions.

Method and Materials

Benthic macroinvertebrate communities were semi-quantitatively sampled between April 27, 2004, and May 4, 2004, using the RBP III method described in the State of Tennessee Department of Environment and Conservation Division of Water Pollution Control *Quality System Standard Operating Procedure* (SOP) *for Macroinvertebrate Stream Surveys.* Depending on stream size, either a one square meter kick net (for larger streams) or a D-frame stationary net (for smaller streams) was used to collect benthic macroinvertebrates. In larger streams, two separate riffle kicks were performed by a two-person crew. One individual held the double handle kick net perpendicular to the current with the net's weighted bottom resting firmly on the streambed. Another person disrupted the substrate with a kicking and sweeping motion in a one square meter stretch just upstream of the net. Benthic organisms were dislodged and drifted into the waiting net. After allowing suitable time for all the debris to flow into the net, the person performing the kick lifted the bottom of the net at each end in a smooth, continuous motion while the person holding the net at the top was careful not to let the top edge dip below the water's surface. After a second riffle was sampled in an identical fashion, the collected organisms were picked from the net and transferred into a container as a composite sample.

At smaller stream sites (e.g., Bear Creek BCK 12.3), where riffles were less than one meter wide, four separate riffle kicks were performed using the one-man, D-frame net. A crewmember held the single handle net perpendicular to the current with the net's bottom pressed firmly to the streambed. The same person disrupted the upstream substrate for an 18-inch distance and the width of the net, dislodging any benthic organisms. After allowing suitable time for all debris to drift into the net, the net was lifted from the water and three additional riffles were sampled in the same fashion. The debris from all four kicks was composited.

Benthic macroinvertebrate samples were preserved in 80% ethanol with internal and external site specific labels. Labeling information included site name, sampling date, and sampler's initials. If more than one sample container was needed at a site, the debris was split evenly with internal and external labels completed for each container.

Sample collection methods were modified in the White Oak Creek watershed due to the presence of radioactive contamination in the stream sediments. The two, 1-meter kick samples were combined in a 5-gallon bucket, creek water was added and the sample swirled to suspend the lighter material (including invertebrates) with the elutriate then being poured through a sieve. This process was repeated five times to ensure the thorough collection of organisms. Any material not needed was returned to the creek. Samples from radioactively contaminated sites were processed in laboratory space designated by ORNL Health Physics personnel.

Once sampling was completed at all sites the sample containers were transported to the State Biology Laboratory in Nashville for processing. Following the State SOP for laboratory sample processing, all samples were sorted and benthic macroinvertebrates were identified and enumerated to the genus level. Using raw benthic data biological metrics were calculated in order to develop an overall site rating. Calculated metrics included Taxa Richness, EPT (Ephemeroptera, Plecoptera, Trichoptera) Richness, Percent EPT, Percent OC (oligochaetes and chironomids), NCBI (North Carolina Biotic Index), Percent Dominant Taxon, and Percent Clingers. Once values were obtained for the seven metrics, a score of 0, 2, 4, or 6 was given to each metric based on comparison to the metric target values for Bioregion 67F, the reference ecoregion for Oak Ridge Reservation streams. The seven scores were totaled and the overall index score (IS) was compared to the Target Index Score (TIS) for Bioregion 67F, TIS = 32. The biological condition rating of the sampling site was estimated within a range of Non-Supporting/Severely Impaired (IS < 10) to Supporting/Non-Impaired (IS >= 32). A description of the metrics and the equations used to calculate them can be obtained by referencing the State SOP. The biometrics used to generate stream ratings and the expected response of each metric to stress introduced to the system are presented in Table 1.

Table 1. Description of Metrics and Expected Responses to Stress

Category	Metric	Description	Response to Stress
Richness Metrics	Number of taxa	Measures the overall variety of the macroinvertebrate assemblage	number decreases
	Number of EPT taxa	Number of taxa in the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)	number decreases
Composition Metrics	% EPT	% of Ephemeroptera, Plecoptera, and Trichoptera	% decreases
	% OC	% of oligochaetes (worms) and chironomids (midges)	% increases
Tolerance Metrics	% Dominant	% contribution of single most dominant taxa	% increases
	NCBI	North Carolina Biotic Index which incorporates richness and abundance with a numerical rating of tolerance	number increases
Habit Metric	% Clingers	% of macroinvertebrates having fixed retreats or attach to surfaces	% decreases

Results and Discussion

East Fork Poplar Creek

The metric values, metric scores, overall index scores, and biological condition ratings of the impacted streams on the ORR are presented in Table 2. EFK 24.4 (IS = 18), EFK 23.4 (IS = 20), and EFK 13.8 (IS = 18) rated partially supporting/moderately impaired compared to Bioregion reference conditions. The three scores were well below the target index score of 32. Stream conditions appeared to improve downstream of EFK 13.8 as EFK 6.3 had a score of 30 and a rating of partially supporting/slightly impaired. Observed responses in the individual metrics generally coincided with those expected with an introduction of stress into the system (Table 1). Most noticeable were an increase in Taxa Richness and a decrease in % OC indicating a greater degree of impact within plant boundaries. The % EPT was between two to four times greater at the lowermost site, EFK 6.3, than at the three upstream sites. Sampling results continue to support the assessment of improving stream conditions with distance from the Y-12 Plant. Conditions in Upper East Fork Poplar Creek continue to impact the biotic integrity of the system.

Mitchell Branch

MIK 1.43 and MIK 0.45 rated partially supporting/slightly impaired with index scores of 30 and 24, respectively. MIK 1.43 has long been considered an upstream reference site for MIK 0.71 and MIK 0.45. From Table 2, the two lower test sites within ETTP had much lower Taxa Richness and % EPT values compared to MIK 1.43. The increase in % OC with distance further suggests impaired stream conditions within the Plant. The degree of suitable habitat and impacts from source pollutants within ETTP continue to limit the composition of benthic macroinvertebrates in lower Mitchell Branch, especially in the remediated portion near MIK 0.71.

White Oak Creek and Melton Branch

A cursory glance at the stream ratings in Table 2 would lead to an assessment of near ideal conditions in Lower White Oak Creek compared to reference conditions at WCK 6.8 as the lowest rating was partially supporting/slightly impaired. A closer examination of the metric values suggests otherwise, especially at WCK 3.9. Depressed EPT Richness and % EPT values at WCK 3.9, WCK 3.4, and WCK 2.3 compared to reference values and a threefold increase in % OC with distance support the assessment of impaired stream conditions inside ORNL boundaries. Impacts appear to be greatest at WCK 3.9 with marked decreases in Taxa Richness, EPT Richness, and % EPT with slight increases downstream. Melton Branch was not sampled in 2004 due to in-stream activities related to the Melton Valley restoration project. The traditional sampling site in Melton Branch lies within the relocated and remediated portion of the stream and could not be sampled.

Bear Creek

Compared to reference conditions, the uppermost site on Bear Creek, BCK 12.3, rated partially supporting/moderately impaired and BCK 9.6 rated partially supporting/slightly impaired. BCK 12.3 is in closer proximity to the Y-12 Plant and associated sources of impact. EPT Richness and % EPT values are much lower at BCK 12.3 compared to BCK 9.6 indicating a greater degree of impact. The % OC is ten times greater at the upper site providing further support of poor stream conditions. Like Mitchell Branch, habitat suitability also appears to be a limiting factor in benthic macroinvertebrate community assemblage at BCK 12.3.

Table 2. Metric Values, Scores, and Biological Condition Ratings for ORR streams

	East Fork Poplar Creek				Mitchell Branch		
METRIC	EFK 24.4	EFK 23.4	EFK 13.8	EFK 6.3	MIK 1.43	MIK 0.71	MIK 0.45
Taxa Richness	13 (2)	19 (2)	24 (4)	16 (2)	44 (6)	30 (4)	30 (4)
EPT Richness	4 (2)	4 (2)	2 (0)	5 (2)	6 (2)	6 (2)	5 (2)
% EPT	18 (2)	12 (0)	9 (0)	36 (4)	31 (4)	22 (2)	18 (2)
% OC	76 (0)	65 (2)	53 (2)	47 (4)	41 (4)	55 (2)	55 (2)
NCBI	4.88 (4)	5.13 (4)	5.36 (4)	4.74 (6)	4.71 (6)	5.36 (4)	5.00 (4)
% Dominant	28 (6)	36 (4)	15 (6)	20 (6)	11 (6)	25 (6)	15 (6)
% Clingers	36.3 (2)	59.3 (6)	29.0 (2)	59.8 (6)	25.9 (2)	17.3 (0)	40.8 (4)
INDEX SCORE	18	20	18	30	30	20	24
RATING	**C**	**C**	**C**	**B**	**B**	**C**	**B**

	White Oak Creek				Bear Creek	
METRIC	WCK 6.8	WCK 3.9	WCK 3.4	WCK 2.3	BCK 12.3	BCK 9.6
Taxa Richness	26 (4)	19 (2)	27 (4)	26 (4)	25 (4)	19 (2)
EPT Richness	11 (4)	5 (2)	7 (2)	7 (2)	3 (0)	6 (2)
% EPT	79 (6)	48 (6)	63 (6)	57 (6)	7 (0)	44 (4)
% OC	10 (6)	34 (4)	25 (6)	27 (4)	82 (0)	8 (6)
NCBI	2.64 (6)	4.83 (4)	5.01 (4)	4.88 (4)	5.89 (4)	4.46 (6)
% Dominant	36 (4)	34 (6)	27 (6)	20 (6)	18 (6)	28 (6)
% Clingers	68.0 (6)	54.5 (4)	52.2 (4)	55.9 (6)	16.9 (0)	52.5 (4)
INDEX SCORE	36	28	32	32	14	30
RATING	**A**	**B**	**A**	**A**	**C**	**B**

Key:
A - Supporting - Non-impaired………………………………….. >= 32
B - Partially Supporting - Slightly Impaired……………………………21 - 31
C - Partially Supporting - Moderately Impaired………………………10 - 20
D - Non-Supporting - Severely Impaired………………………………< 10

Conclusions

The overall biotic integrity of streams on the ORR continues to be less than optimal compared to reference conditions. Based on benthic macroinvertebrate community assessments only two sites, both in White Oak Creek, showed signs of supporting/non-impaired conditions. The remaining nine test sites had biological condition ratings of partially supporting systems with slight to moderate impairment. General trends of improving stream conditions with distance from DOE influences were exhibited in East Fork Poplar Creek and Bear Creek near the Y-12 Plant and in Mitchell Branch at ETTP. White Oak Creek exhibited worsened conditions through decreased ratings as the creek flowed through the ORNL facility. Surface water sampling results continue to provide snapshots of water quality conditions that may play a role in the biotic integrity of a system. The degree of habitat suitability remained a factor in assessing stream conditions, especially at MIK 0.71 and BCK 12.3. Continued assessments of benthic macroinvertebrate communities in ORR streams will add to the current database of information. Biomonitoring in this fashion would facilitate the capture of temporal and spatial changes in the aquatic systems due to DOE related activities. Environmental remedial actions taken by DOE continue to have an impact on the aquatic environments in East Fork Poplar Creek, Bear Creek, Mitchell Branch, and in the White Oak Creek watershed. Benthic macroinvertebrate sampling will resume in Melton Branch in 2005. Documented changes in the benthic communities may provide useful information regarding the effectiveness of Melton Valley remedial activities.

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CHAPTER 3 DRINKING WATER

Sampling of Oak Ridge Reservation Potable Water Distribution Systems

Principal Author: Roger Petrie

Abstract

As the three Department of Energy (DOE) Oak Ridge Reservation (ORR) plants become more accessible to the public, the Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division (DOE-O) has expanded its oversight of the DOE facilities' safe drinking water programs. The scope of TDEC DOE-O's independent sampling includes oversight of potable water quality on or impacted by the ORR. TDEC conducted oversight of backflow prevention devices and sanitary surveys at ORR facilities. The results of these inspections revealed that the three reservation systems provide water that meets State regulatory levels. The distribution system at Y-12 does have some deficiencies in their Cross Connection Control Program, as noted in the sanitary survey.

Introduction

Public consumption of the water on the Oak Ridge Reservation (ORR) continues to increase. In order to facilitate technology transfer, work for non-governmental sectors, and utilization of surplus buildings by private companies, security has been relaxed or reprioritized in recent years at some portions of the sites, most notably at East Tennessee Technology Park (ETTP). In turn the composition of the workforce at the ORR has changed substantially. Oak Ridge National Laboratory (ORNL) has always hosted foreign dignitaries and accommodated visiting scientists in an openly cooperative manner. The other two sites, ETTP and Y-12, until recent years allowed only limited public visitation. Current facility use involves a substantial public presence at ETTP and ORNL, and to a lesser extent at Y-12.

Methods and Materials

Although TDEC will conduct independent sampling when situations indicate that the quality of drinking water in an ORR distribution system may be compromised or that the general integrity of the system is in doubt, the objective of this task was to conduct oversight of all aspects of drinking water supply at the three ORR facilities. The oversight included checking inspection dates on backflow prevention devices as well as attendance at sanitary surveys conducted by personnel from the TDEC Division of Water Supply (DWS).

Results and Discussion

DOE-O personnel conducted an inspection of backflow prevention devices (BFPs) at ETTP on February 10, 2004, to insure that the annual inspections of these devices were up to date. Of the 56 currently active BFPs, a total of 35 were inspected. All 35 devices had up to date annual inspection tags. The devices inspected and the last dates of inspection are shown in Table 1.

Table 1. Backflow Prevention Devices Checked at ETTP

Bldg.	Equipment #	Last Inspection
K1008-D	28-0213	3/7/03
K1037	28-0237	3/7/03
K1037	28-0238	4/3/03
K1039-1	28-0227	5/9/03
K1515	28-0203	5/20/03
K1037	28-0222	6/24/03
K1330	28-0204	7/11/03
K1330	28-0205	7/11/03
K1006	28-0063	7/15/03
K1006	28-0064	7/15/03
K1006	28-0061	7/21/03
K1006	28-0062	7/21/03
K1501	28-0095	7/24/03
K1407-K	28-0188	8/1/03
K1419	28-0174	8/1/03
K1435-U	28-0208	8/6/03
K1650	651	8/7/03
K1580	28-0225	8/15/03

Bldg.	Equipment #	Last Inspection
K1407-J	28-0189	8/25/03
K1650	650	8/27/03
K1037	28-0240	9/11/03
K1037	28-0239	9/11/03
K1435-U	28-0245	9/29/03
K1008-F	28-0194	10/21/03
K1414	28-0029	10/21/03
K1225	28-0046	10/21/03
K1037	28-0242	12/16/03
K1501	28-0201	12/17/03
K1501	28-0202	12/17/03
K1004-J	28-0141	1/13/04
K1004-J	28-0142	1/14/04
K1006	28-0243	1/15/04
K1006	28-0244	1/15/04
K1435-C	28-0167	1/31/04
K1035	28-0133	2/9/04

On August 31, 2004, DOE-O personnel accompanied DWS personnel on the sanitary survey of the ETTP water treatment plant and distribution system. Initial results of the review indicate that for the most part, the system meets or exceeds all required operating parameters. The only areas that were noted as possibly needing improvement were in the area of record keeping methodology. Specifically, the method used to record turbidity at the water treatment plant. This was of interest due to the fact that reporting requirements will change in 2005 due to new regulations. Another area of discussion centered on the monitoring of THM's. This sampling is conducted at the far reaches of the distribution system and the locations of the sampling were discussed. It should be noted that this was not deemed a deficiency by DWS. A review of backflow prevention device records was also discussed as required. No current deficiencies were noted in these records.

On September 20, 2004, DOE-O personnel accompanied DWS personnel on the sanitary survey of the ORNL water distribution system. Initial results of the review indicate that for the most part, the system meets or exceeds all required operating parameters. No deficiencies were noted during the survey. In fact, ORNL was noted for their TTHM and HAA5 sampling. This sampling has profiled the levels of these two substances in the system in relation to residual chlorine levels as well as temperature levels. This data was then correlated to the levels of TTHM and HAA5 to demonstrate the relationship, or lack thereof, between these factors. KEAC personnel noted that this is extremely helpful to them and should prove very beneficial to ORNL in the future.

On September 23, 2004, DOE-O personnel accompanied DWS personnel on the sanitary survey of the Y-12 water distribution system. Initial results of the review indicate that for the most part, the system meets or exceeds all required operating parameters. Several items were noted that might be of concern.

- The West 16” line still feeds back into the main line going to ORNL. This was noted in previous inspections.
- Due to the management structure at Y-12, the system operator does not have the authority to disconnect water service to a facility even if inadequate cross connection controls are found. The disconnect must go through a series of management steps before this can happen.

Of special interest is that there is a proposal to install a new potable distribution system at Y-12. The existing system would then be converted into a dedicated fire protection system. Currently, the potable system and the fire protection system are integrated into one system. This proposal is far from assured and completion of this conversion, if it were to take place, would take several years.

The Y-12 system received a rating of “PROVISIONAL.” In addition, Y-12 received a Notice Of Violation (NOV) from DWS for deficiencies related to their Cross Connection Control Program. Y-12 submitted a course of action to correct these deficiencies and will be subject to a follow up sanitary survey to be conducted in 2005.

The White Oak Dam located on White Oak Creek is of sufficient size to fall under the authority of the Federal Energy Regulatory Commission (FERC). FERC inspects dams periodically to determine if the structure of the dam is in good repair and sufficient for the hazards associated with the body of water being held back by the dam.

During this inspection no apparent deficiencies were noted with the White Oak Dam. In fact, the FERC inspectors noted that, if anything, the dam was over engineered for the quantity of water that is being retained behind it. Given the hazards associated with White Oak Lake, this is considered to be beneficial. Interim inspections of the dam, conducted by Duratek for UT-Batelle, indicate that there is no movement of the dam. This indicates that there is no settling of dam occurring.

A review of the final FERC inspection report was conducted on site since information in the report was deemed sensitive and not meant for public dissemination. The report indicated that no conditions were found that should adversely affect the immediate safety of the dam. Also, no maintenance deficiencies were noted during the inspection and no safety issues were identified. Based on these findings, the status of the dam is unchanged.

During the last two weeks of September 2004, a new water line was placed under the Clinch River to supply drinking water to the new Rarity Ridge subdivision located on the old Boeing property. DOE-O planned to collect samples during drilling but was unable to be on site during drilling. After installation of the pipe was completed, division staff conducted a radiological walkover of the area where material had been deposited from the coring operation. The results of this walkover indicated that there was no contamination present, since all radioactivity readings were not above natural background.

Conclusion

The results of these inspections revealed that the three reservation systems provide water that meets State regulatory levels. The distribution system at Y-12 does have some deficiencies in their Cross Connection Control Program, as noted in the sanitary survey.

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CHAPTER 3 DRINKING WATER

Implementation of EPA's Environmental Radiation Ambient Monitoring System (ERAMS) Drinking Water Program (RMO)

Principal Authors: Howard Crabtree, Natalie Pheasant

Abstract
The Environmental Radiation Ambient Monitoring System was developed by the U.S. Environmental Protection Agency (EPA) to monitor potential pathways for significant population exposures from routine and/or accidental releases of radioactivity from major sources in the United States (U.S. EPA, 1988). This program provides for radiochemical analysis of finished water at five public water supplies located near and on the Oak Ridge Reservation. In this effort, quarterly samples are taken by personnel from the Tennessee Department of Environment and Conservation to be analyzed at the EPA's National Air and Radiation Environmental Laboratory in Montgomery, Alabama. Although data from the program indicate tritium, gross beta, and strontium-90 results are higher for the Gallaher Water Treatment Plant than the four other systems monitored in the program, the results received from EPA to date have all been well below regulatory criteria.

Introduction
Radioactive contaminants released on the Oak Ridge Reservation (ORR) enter local streams and are transported to the Clinch River. While monitoring of these streams, the river, and local water treatment facilities has indicated that concentrations of radioactive pollutants are below regulatory standards, there has remained a concern that area public water supplies could be impacted by ORR pollutants. In 1996, the Tennessee Department of Environment and Conservation Department of Energy Oversight Division (the division) began participation in the Environmental Protection Agency's (EPA) Environmental Radiation Ambient Monitoring System (ERAMS). This program provides radiological monitoring of finished water at public water supplies near nuclear facilities throughout the United States. The ERAMS program was designed to:

1. Monitor pathways for significant population exposure from routine and/or accidental releases of radioactivity;
2. Provide data indicating additional sampling needs or other actions required to ensure public health and environmental quality;
3. Serve as a reference for data comparisons (U.S. EPA, 1988)

The ERAMS program also provides a mechanism to evaluate the impact of DOE activities on area water systems and validate DOE monitoring in accordance with the *Tennessee Oversight Agreement* (TDEC, 2001).

Methods and Materials
In the Oak Ridge ERAMS Program, EPA provides radiochemical analysis of finished drinking water samples taken quarterly by division staff at five public water supplies located on and in the vicinity of the ORR. The samples are collected using procedures and supplies prescribed in *Environmental Radiation Ambient Monitoring System (ERAMS) Manual* (U.S. EPA, 1988). ERAMS analytical frequencies and parameters are provided in Table 1.

Table 1: ERAMS Analysis for Drinking Water

ANALYSIS	FREQUENCY
Tritium	Quarterly
Gamma Scan	Annually on composite samples
Gross Alpha	Annually on composite samples
Gross Beta	Annually on composite samples
Iodine-131	Annually on one individual sample/sampling site
Radium-226	Annually on samples with gross alpha >2 pCi/L
Radium-228	On samples with Radium-226 between 3-5 pCi/L
Strontium-90	Annually on composite samples
Plutonium-238, Plutonium-239, Plutonium-240	Annually on samples with gross alpha >2 pCi/L
Uranium-234, Uranium-235, Uranium-238	Annually on samples with gross alpha >2 pCi/L

The five Oak Ridge area monitoring locations are: Kingston Water Treatment Plant, Gallaher (K-25) Water Treatment Plant, West Knox Utility, City of Oak Ridge Water Treatment Facility (formerly DOE Water Treatment Plant at Y-12), and Anderson County Utility District. Figure 1 depicts the approximate locations of raw water intakes associated with these facilities.

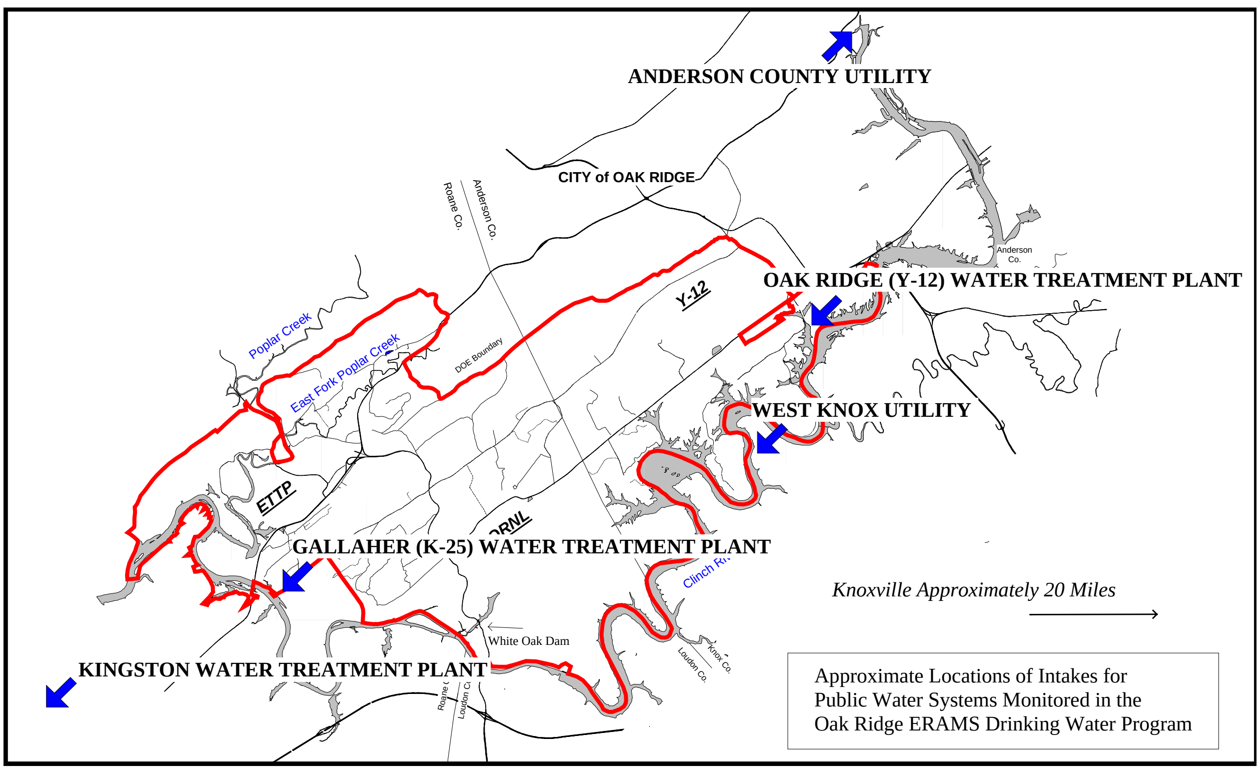

Figure 1: Approximate Locations of the Intakes for Public Water Systems monitored in Association with EPA's Environmental Radiation Ambient Monitoring System (ERAMS) Drinking Water Program

Results and Discussion

A large proportion of the radioactive contaminants that are transported off the ORR in surface water enter the Clinch River by way of White Oak Creek, which drains the Oak Ridge National Laboratory complex and associated waste disposal areas. When contaminants carried by White Oak Creek and other ORR streams enter the Clinch, their concentrations are significantly lowered by the dilution provided by the waters of the river. With exceptions, contaminant levels are further reduced in finished drinking water by conventional water treatment practices used by area utilities. Consequently, the levels of radioactive contaminants measured in the Clinch and at area water supplies are far below the concentrations measured in White Oak Creek and some of the other streams on the ORR.

Since the Gallaher Water Treatment Plant is the closest water supply downstream of White Oak Creek (approximately 6.5 River Miles), this facility would be expected to exhibit the highest concentrations of radioactive contaminants of the five utilities monitored in the program. Conversely, the Anderson County Facility (located upstream of the reservation) would be expected to be the least vulnerable to ORR pollutants. Based on the data collected since the Oak Ridge ERAMS Program began in July 1996, the above appears to be the case. Gross beta, strontium-90, and tritium have all been reported at higher levels in samples taken from the Gallaher Water Treatment Plant than at the other facilities monitored in the program. However, the results for the Gallaher Facility, as well as the other sites, have all remained well below applicable drinking water standards. A brief summary of the results received since the Oak Ridge program began follows.

Since 1997, gross alpha, gross beta, and strontium-90 analysis has been performed annually on a composite of the quarterly samples taken from each facility. These results are summarized below for the data received to date.

- Gross alpha results were all below 2.0 pCi/L, compared to a drinking water standard of 15 pCi/L.
- The highest gross beta result for the annual composite analysis was reported for the Gallaher Facility, which averaged 3.25 pCi/L with a maximum concentration of 3.86 pCi/L. The drinking water standard for beta emitters depends on the specific radionuclides present, but radionuclide specific analysis is generally not required at gross beta levels below 50 pCi/L.
- Of twenty-five composite samples analyzed for strontium-90 (a beta emitter), the only results reported above detection limits were for samples taken at the Gallaher Facility. These results indicate three of the four samples analyzed had low, but detectable, amounts of the radionuclide. The average result was 0.58 pCi/L and the data ranged from 0.29 to 0.99 pCi/L. The drinking water standard for strontium-90 is 8 pCi/L.

Analysis for iodine-131 was performed each year since 1996 on one sample from each facility. The radionuclide was only reported as detected in one of thirty-one samples analyzed. This result, 0.3 pCi/L, was from a sample taken upstream of the reservation, making the validity of the measurement suspect. The standard for iodine-131 is 3.0 pCi/L.

ERAMS performs tritium analysis on each of the quarterly samples taken at the facilities in the program. Tritium is not readily removed by conventional treatment processes and is one of the most prevalent contaminants discharged by White Oak Creek into the Clinch River. Of the 172 tritium results reported for the five Oak Ridge Treatment Plants, only 24 were above detection limits. From the sample results above detection limits, 21 were from samples taken at the Gallaher Facility and three were reported for the Kingston Facility, further downstream. The results for tritium at the Gallaher Facility ranged from undetected to 1000 pCi/L and averaged 285 pCi/L. The drinking water standard is 20,000 pCi/L.

The results received from ERAMS for 2004 (tritium and iodine-131), are similar to those received in past years. All iodine-131 results were below detection limits, as is the case for the tritium results, except for two values reported for the Gallaher Facility (276 pCi/L and 281 pCi/L). The average activities for 2004 data are provided in Figure 2. It should be noted, the instruments used in radiochemical analysis produce a slight reading due to the electronics associated with the equipment. This "instrument background" is determined prior to analysis and subtracted from the results. When the concentrations are low, it is not unusual for this to result in negative values, as can be seen in Figure 2.

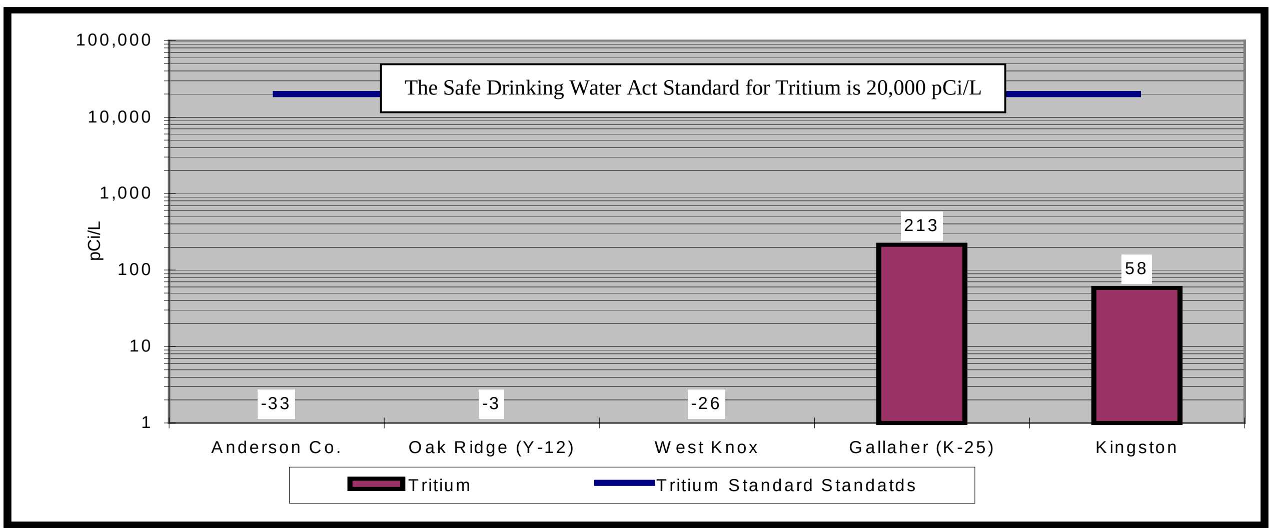

Figure 2: 2004 Average Tritium Results for Samples of Finished Drinking Water taken at Oak Ridge Area Water Treatment Facilities in Association with EPA's ERAMS Program

Conclusion

Radioactive contaminants migrate from the ORR to the Clinch River, which serves as a raw water source for area public drinking water supplies. The impact of these contaminants is diminished by the dilution provided by waters of the Clinch. Contaminant concentrations are further reduced in finished drinking water by conventional water treatment practices employed by area utilities. ERAMS results over the last eight years have all been well below drinking water criteria. While below drinking water standards, gross beta, strontium-90, and tritium have all been reported at higher levels in samples taken from the Gallaher Water Treatment Plant than the other facilities monitored in the program. In this respect, the Gallaher plant is the closest facility downstream of White Oak Creek, the major pathway for radiological pollutants entering the Clinch from the ORR.

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CHAPTER 3 DRINKING WATER

Radiological Analysis of Drinking Water at Oak Ridge National Laboratory

Principal Author: Roger Petrie

Abstract
The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division conducted sampling of drinking water at Oak Ridge National Laboratory (ORNL) for radiological contaminants. This sampling addressed the possible infiltration of radiological contaminants into the ORNL drinking water distribution system in the vicinity of the High Flux Isotope Reactor (HFIR). Results of the sampling indicate that at the time of sampling there were no radiological contaminants in the drinking water system in the vicinity of HFIR.

Introduction
The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division conducted sampling of drinking water at Oak Ridge National Laboratory (ORNL) for radiological contaminants. This sampling addressed the possible infiltration of radiological contaminants into the ORNL drinking water distribution system in the vicinity of HFIR.

This area has been identified as having extensive subsurface radiological contamination. The sampling aided the identification of infiltration, or the presence of any cross connections that were present at the time of sampling. This plan also serves as a template for additional sampling at ORNL, or the other DOE facilities, in the event of a large pressure drop of the distribution system due to major failure or significant water loss from firefighting or flushing.

Methods and Materials
Analysis of distribution maps and schematics was utilized to identify five locations in the area of HFIR. In addition, a background sample was collected at the Oak Ridge Water Treatment Plant (ORWTP) as a control. The sites and dates sampled are shown in Table 1.

Table 1.
Locations of Drinking Water Sampling at ORNL

Site	Date
Bldg. 7964G	10/11/2004
Bldg. 7910	10/11/2004
Bldg. 7900	10/11/2004
Bldg. 7930	10/11/2004
Bldg. 7920	10/11/2004
ORWTP	10/11/2004

The samples were analyzed for presence of bacteria, gross alpha and beta emitters, and gamma radionuclides.

When other locations are being sampled, the parameters analyzed for will vary depending upon the contaminants of concern in the area of the distribution system failure. The parameters analyzed will be chosen from process knowledge and other gathered data, e.g. plume maps, Remedial Investigations etc.

Results and Discussion

All six samples collected tested negative for the presence of bacteria. The results of the analysis for gross alpha and beta emitters are shown in Table 2. These results indicate that there is no contamination present that can be attributed to alpha or beta emitters.

Table 2.
Results of Gross Alpha and Beta Analysis (pCi/L)

Site	Gross Alpha	Gross Beta
Bldg. 7964G	0.4 ± 1.4	-0.2 ± 1.1
Bldg. 7910	0.0 ± 1.4	1.1 ± 1.3
Bldg. 7900	0.4 ± 1.5	0.6 ± 1.2
Bldg. 7930	-0.4 ± 1.2	1.2 ± 1.3
Bldg. 7920	0.0 ± 1.3	0.8 ± 1.2
ORWTP	-0.8 ± 1.1	0.5 ± 1.2

The results of the analysis for gamma radionuclides are shown in Table 3. These results show the presence of only naturally occurring radionuclides at levels that do not pose a risk to human health.

Table 3.
Results of Gamma Radionuclide Analysis (pCi/l)

Site	Bi-214
Bldg. 7964G	
Bldg. 7910	13.3 ± 3.8
Bldg. 7900	
Bldg. 7930	
Bldg. 7920	
ORWTP	

Conclusion

Based on the results of the analysis conducted on the samples, there is no evidence at this time that there is any intrusion of contaminants from the Corehole 8 area into the ORNL drinking water distribution system. It should be noted that these were grab samples, which represent a snapshot in time, and does not mean that contamination will not be present in the future.

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CHAPTER 4 GROUNDWATER MONITORING

Oak Ridge Reservation and Vicinity Independent Sampling Report

Principal Authors: John E. Sebastian, Donald F. Gilmore, Robert C. Benfield

Abstract

Description of program – Scope of Monitoring

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) conducts independent groundwater sampling at springs, wells, and integrated surface sampling sites on or near the Oak Ridge Reservation. The calendar year 2004 groundwater-sampling projects included eighteen (18) exit pathway springs and three (3) surface water sites integrated with groundwater monitoring. Exit pathway springs in the peripheral areas of the Oak Ridge Reservation were monitored for determination of quality and effectiveness of the Department of Energy's (DOE) monitoring and surveillance programs. Samples were analyzed for radiochemicals, organic solvents, metals, inorganics, and nutrients, on a case by case basis dependent on expected and potential contaminants known or suspected contaminants at the sites being monitored. This chapter provides a status/review of the division's Environmental Monitoring & Compliance Program's Groundwater Section's findings based on sampling performed during the calendar year 2004.

Introduction

This chapter provides a status/review of the division's Environmental Monitoring & Compliance Program's Groundwater Section's findings. The Groundwater Section staff sampled eighteen (18) exit pathway springs and three (3) surface water sources (Figure 1, Table 1). These findings are based on sampling performed during calendar year 2004 (CY2004).

The Tennessee Oversight Agreement (TOA) with the Department of Energy (DOE) specifies the State to prepare a report of sampling results. Also the TOA mentions the reporting of *findings* based on the State's analytical results. With respect to the TOA's requirements and the following definitions, this chapter attempts to integrate results and findings as an independent comprehensive groundwater monitoring report.

- To monitor is to measure (gauge, calculate, determine, assess, quantify, evaluate, appraise, etc.) some aspect of groundwater;
- To sample is to extract some portion of a larger system of groundwater for testing.

The State is not inherently responsible for the groundwater monitoring of the Oak Ridge Reservation (ORR), rather it is DOE's responsibility to "monitor and surveil" groundwater contamination on the ORR and its environs. It is however the State's duty to provide independent oversight of the DOE groundwater monitoring program. The State is not limited in this duty and "independent monitoring," "supplemental monitoring" and other specific actions have proved to be the most effective means of addressing concerns over and inadequacies observed in DOE's monitoring programs. At times the State's performance of this function has lead to quantitative and qualitative improvements in DOE's monitoring and surveillance of contaminated groundwater on the ORR. A defensible argument can be made that this independent driver function of State monitoring of the ORR and environs groundwater is and has been a most valuable even indispensable part of maintaining the Division's mission, which is to protect the environment and people of Tennessee.

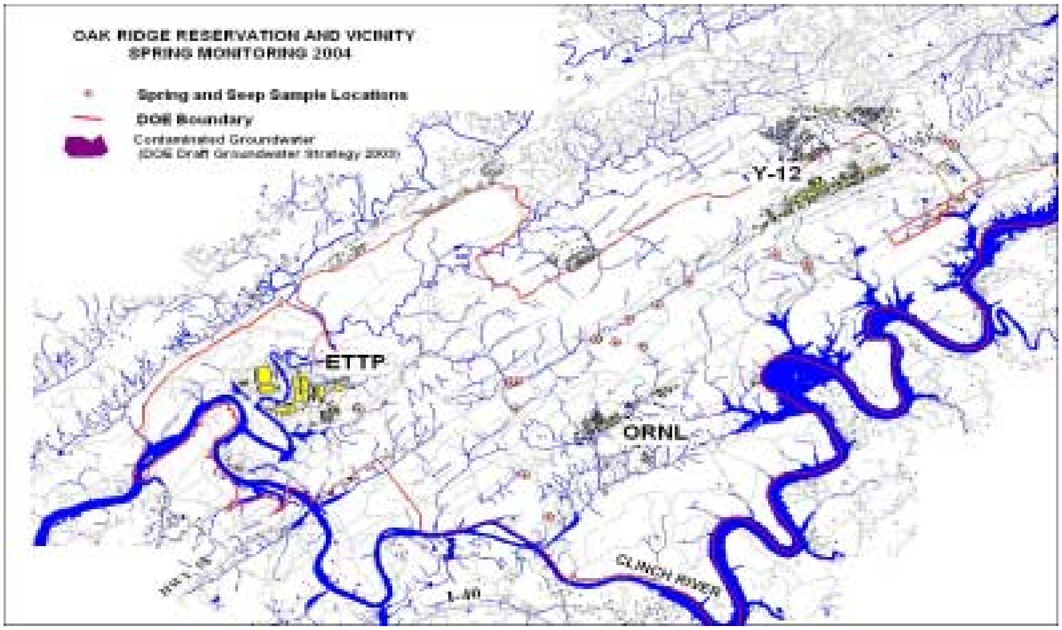

Figure 1. Oak Ridge Reservation and Vicinity Spring Monitoring 2004 Locations

Table 1 List of Sites Sampled CY2004	
Site	**Station**
ETTP (K-25)	Doug's Drip Sp.
	Itchy Sp.
ORNL (X-10)	Burns Cemetery
	Crooked Tree Sp.
	Raccoon Creek Sp.
	SNS-1 Sp.
	SNS-4 Sp.
Y-12	Bootlegger Sp.
	Cattail Sp.
	Cabin Sp
	Cephus Sp.
	Little Dipper
	SS-7 Sp.
	SS-6 Sp.
	SS-5 Sp.
	SS-4 Sp.
	SS-8 Sp.
	MVMR/Mossy Rock Sp.
	New Weir
	Bear Creek @ SS6
	Bear Creek Km 4.78

Exit Pathway Monitoring

Effective monitoring of contaminants being transported by groundwater is largely a process of identifying and sampling the pathways by which the groundwater leaves the contaminated areas. Thus a significant portion of the Division's groundwater sampling has been directed toward identifying and monitoring exit pathways on the ORR.

Given the nature of groundwater flow on the ORR, very effective monitoring may be conducted by sampling springs and seeps on and around the reservation. Springs and seeps represent convergent point where groundwaters emerge on the ORR and often represent the interface between contaminated groundwater and surface water affected by that contamination.

In the past, the division has been very effective in discovering contaminated and previously unmonitored new springs and seeps. Such discoveries have contributed greatly to the understanding of contaminant movement on the ORR and doubtless there are significant such discoveries remaining to be made.

Monitoring Known Contaminated Groundwater

Significant areas of the ORR are underlain by contaminated groundwater and the DOE performs extensive sampling of monitoring wells within these areas. Review and comments on annual reports regarding this monitoring is a task performed by the division as part of its TOA responsibilities.

The aquifers and the so-called "aquitards" (all bedrock units underlying the ORR qualify as aquifers by definition even if some minority of bedrock aquifers are in fact very poor producers for domestic water) in East Tennessee are vulnerable to contamination and plumes spread rapidly. This concern is echoed in DOE's position to control, through deed restrictions or notices, many areas of groundwater use in the environs about the ORR. For this and other reasons, contact with groundwater on the ORR should be avoided. It is inevitable that long term monitoring of groundwaters in and around the ORR will be necessary to protect the people and environment of East Tennessee from the legacy of DOE operations.

Methods and Materials

The State Environmental Laboratory conducts the analysis of the water samples for radionuclides, volatile organic compounds, selected metals, nutrients, and inorganic parameters. The division's spring sampling activities typically include the parameters found in Table 2.

Finding new springs. Springs are normally found by walking along creeks and valleys and found often emerging in streambeds. Specific vegetation such as watercress, willow and sycamore trees is a common indicator of groundwater resurgence (i.e. springs). Careful use of temperature and specific conductivity measurements help delineate groundwater resurgences and even separate different resurgences occurring within the same spring. In the areas of contaminant plumes, orange staining caused by iron related bacteria breaking down organic compounds also helps identify locations to sample. Smells or odors that may be sweet or stringent may contribute to the ability of locating a spring. However, if odors are noticed steps must be taken to insure the health and safety of samplers and others by notifying appropriate health and safety personnel.

1. Field sampling. A sampling team locates the spring and collects the prescribed number of

Table 2. Parameters

Nutrient, Metal & General Inorganic Analysis	Radiological Analysis	List of TCL* Volatiles
Metals	Typically	Acetone
Arsenic	Gross Alpha	Benzene
Barium	Gross Beta	Bromodichloromethane
Cadmium	Gamma Emitters	Bromoform
Calcium	Tritium	Bromomethane
Copper		2-Butanone (MEK)
Iron	If suspected then isotopes of:	Carbon Disulfide
Lead	Strontium	Carbon Tetrachloride
Magnesium	Technetium	Vinyl Acetate
Mercury	Uranium	Chlorobenzene
Nickel	Radium	Chloroethane
Potassium		Chloroform
Selenium		Chloromethane
Sodium		Dibromochloromethane
Thallium		1,1-Dichloroethane
		1,2-Dichloroethane
General Inorganics		1,1-Dichloroethene
pH		Cis-1,2-Dichloroethene
Specific Conductivity		Trans-1,2-Dichloroethene
Total Alkalinity		1,2-Dichloropropane
Suspended Residue		Cis-1,3-Dichloropropene
Dissolved Residue		Trans-1,3-Dichloropene
Sulfate		Ethylbenzene
Chloride		Methylene Chloride
		4-Methyl-2-Pentatone (MIBK)
		Styrene
Nutrients		2-Hexanone
NO3&NO2 Nitrogen		1,1,2,2-Tetrachloroethane
		Tetrachloroethene
		Toluene
		1,1,1-Trichloroethane
		1,1,2-Trichloroethane
		Trichloroethene
		Vinyl Chloride
		o-Xylene
		m & p xylene
		*TCL (Target Compound List)

samples. The personnel wear disposable vinyl gloves while collecting samples. Sample labels (tags) and analysis request/chain of custody forms are completed. Samples are transported in coolers to the division's office for temporary storage, or may be taken directly to the Knoxville Basin Laboratory. Duplicate samples, trip blanks, and field blanks are taken as directed by the sampling plan.

2. Data Storage. Analytical results are stored in regular files in the DOE-O office, and the results are entered in a computer database. Eventually this data will be placed onto DOE's Oak Ridge Environmental Information System database. Copies of the lab analyses are periodically provided to DOE upon request.

Results and Discussion

Groundwater General

Groundwater is the primary and initial mode of contaminant migration within ORR. To a great extent surface water contamination on the ORR begins as contaminated groundwater from various disposal trenches, land-farms, and areas where contaminants were apparently simply spilled emerges either in springs and seeps or as direct recharge into streambeds. Understanding the nature and movement of groundwater within the ORR is to understand the initial movement of contaminants from the ORR.

Geology on the ORR consists of Ordovician and Cambrian clastic and carbonate units thrust faulted into place with a resulting trend that is dominantly toward the Northeast - the bedding of these rocks predominantly dips towards the southeast at angles between twenty and forty-five degrees. The geologic structure controls the movement of groundwater with the along strike component being the predominant and cross strike irregularities being important within particular rock units. To this date sampling has not shown contaminants moving by groundwater to have crossed the regional strike of the rock units and to thus have moved off the reservation toward the northeast or southwest, Contaminant migration along strike is however well documented and can be shown in two instances to carry contaminants across ORR boundaries.

Groundwater movement within the ORR is demonstrably dominated by flow along remnant structures within the regolith above the bedrock and turbulent rapid flow in the bedrock along dissolution enhanced fractures in the karts units and along fractures within the clastic rock. Other types of flow particularly matrix flow are insignificant in this hydrogeologic regieme.

The Clinch River appears to be a major natural feature buffering offsite water sources from DOE groundwater impacts. This statement pertaining to the Clinch River as a hydrologic divide for groundwater predominantly stands true. Many springs issue along the riverbed in support of this statement; however, the critical base flow elevation of groundwater is not known. The ORR area is underlain by karst and fractured clastic aquifers. Particularly in the areas underlain by karst aquifers conduits may exist that have base levels below the Clinch River. There is a concern in the vicinity of the Hydrofracture underground waste injection projects that large pressures exerted during waste disposal potentially could also have had the force to underflow the Clinch River. The critical locations where monitoring by DOE needs to take place both on and off DOE property is in conjunction with the hydrofracture injection at Oak Ridge National Lab (ORNL or X-10).

Significant areas to the east of the ORR are not however bounded by the Clinch River and indeed it has been determined that plumes do cross the ORR boundary and impact waters offsite. In particular, plumes have been demonstrated to exist in Union Valley east of the Y-12 plant, and within Chestnut Ridge East of the Security Pits. Significantly both these plumes are within well-developed dissolution enhanced turbulent conduit aquifers hosted by soluble rock karst aquifers namely the Maynardville Limestone and the dolomite of the Knox Group.

In general, calendar year 2004 showed little change from 2003 sampling, in part this is due to a continuation of anomalously large yearly rainfall totals. Unavoidable personnel difficulties in the division's Groundwater Monitoring staff worked to diminish the absolute number of samples obtained in 2004.

Exit Pathway Springs General

In general terms DOE compliance monitoring showed heavily contaminated groundwater near spills and releases on the ORR. Several springs near Y-12 and East Tennessee Technology Park (ETTP or K-25) were found to have conspicuous smells and vapors observed by samplers in 2003. As in 2003, higher water table conditions appear to have had an effect altering concentrations at the University of Tennessee's Bootlegger Spring and at Cattail Spring in Union Valley. Bootlegger's and Cattail's VOCs were only detected in the later part of the year at lower spring flows when plume signatures reappeared. Both of these plumes have shown contamination in the two springs for extended periods, any hiatus in results detecting VOCs should be considered the result of anomalous conditions.

The concern in 2003 regarding locations becoming inundated with beaver ponds continued as a problem into and through 2004. Beaver ponds caused sampling to be postponed at locations like SS-7 and SS-8 on Bear Creek. As an addendum to this concern this location appeared to be clear of the beaver pond when visited in early 2005, hopefully a full calendar year of sampling can be obtained from these important exit pathway springs in Bear Creek Valley.

Exit Pathway Springs ETTP (K-25)

From a groundwater standpoint, monitoring in and around ETTP is not as complete as it could be. Plumes are not well defined and sampling of sites that showed VOCs in conjunction with noticeable odors were discontinued awaiting the acquisition of proper safety equipment (Figure 2).

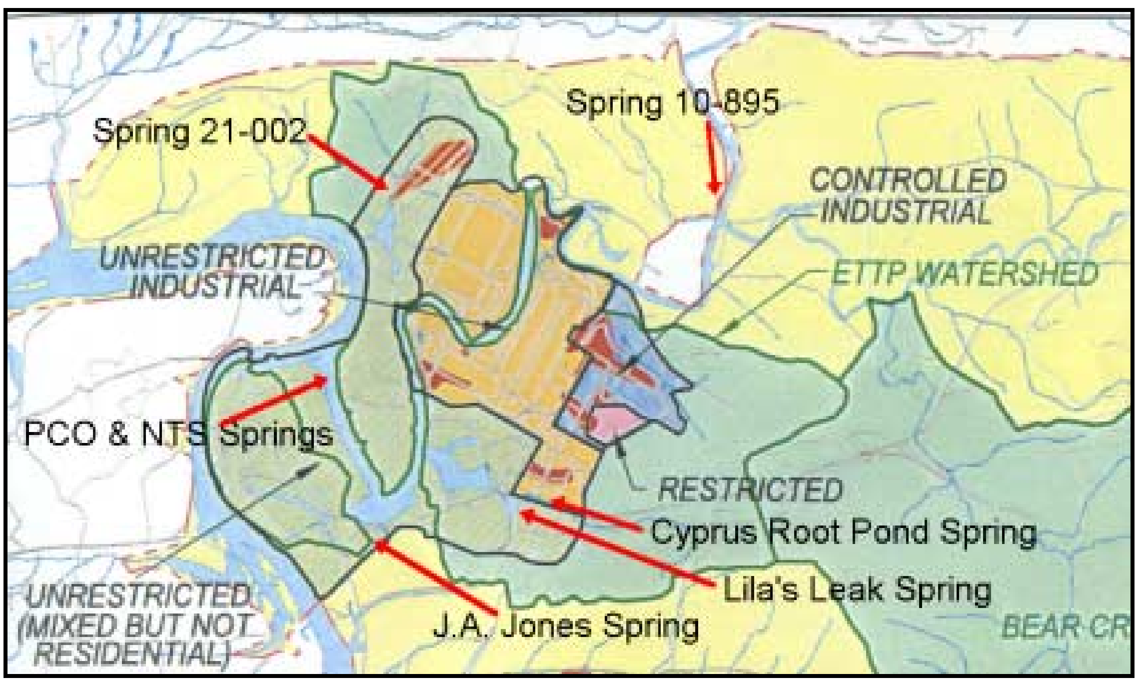

Figure 2. Map of K-25 area showing plumes as red or dark patches. Spring locations are not near mapped plumes except Spring 21-002. To achieve effective monitoring plumes will have to be better understood in relation to impacted springs

Considering the large number of wells that have been emplaced it is conspicuous for large areas that have very poor or no coverage for groundwater that is most probably contaminated. In general this is true for bedrock over the majority of ETTP and in particular for areas to the south of the main plant near HWY 58. It is for the most part a mistake in saying that no contamination exists where there are no wells. In October 2000 DOE's Independent Investigation of the ETTP noted: *"Weaknesses in the environmental restoration program at the ETTP site include ongoing delays in remedial decision-making, incomplete identification and evaluation of past potential disposal and release locations, incomplete groundwater contamination characterization, and the absence of effective mitigation actions for continuing releases of chemical and radiological contaminants."*

ETTP has a significant need for more wells and groundwater tracing to understand the distribution of contaminated water at ETTP. Exit pathway springs should be monitored for both releases and remediation effects.

Exit Pathway Springs X-10

The acetone found in samples from Burns Cemetery Spring and Crooked Tree Spring in 2003 was not seen in 2004 samples; it is most probable the acetone was the result of some error in the sampling, handling or analysis. The limited sampling performed by the DOE-O division (Figure 3) did not show any contamination but resources applied were of such a limited nature that it would be erroneous to conclude that ORNL groundwater had become suddenly benign.

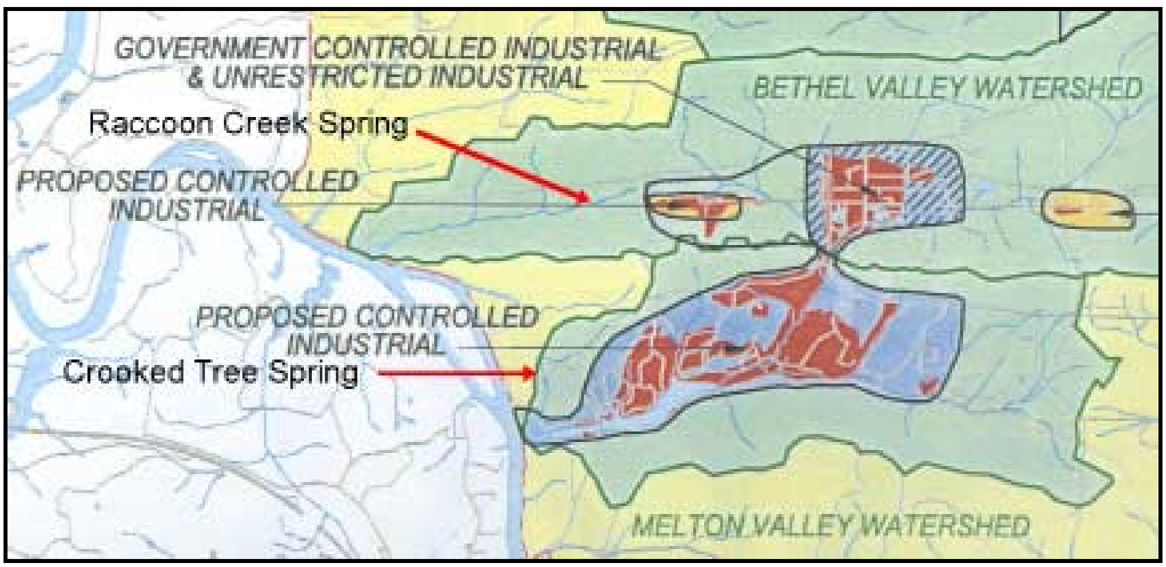

Figure 3. Oak Ridge National Laboratory (ORNL or X-10) Note plume pathways are not drawn to impacted springs.

Exit Pathway Springs Y-12

Bootlegger Spring in the University of Tennessee Arboretum has shown through past sampling VOCs associated with the Security Pits disposal area on Chestnut Ridge near Y-12. Sampling in 2004 reflected 2003 in that VOCs only appeared during low flow conditions late in the year.

Conclusions

The goal of oversight is to provide a joint assessment of surveillance and monitoring for comprehensiveness and integration. In addition, it is DOE's responsibility to provide the public with information on releases both past and present, it is the State's oversight mission to assure that this is accomplished in a timely and accurate manner. It is intended that an independent monitoring program perform as a check on the task of DOE in providing information on releases.

Effective monitoring and surveillance of groundwater plumes therefore is the goal to evaluate in this report. Given the seriousness of the waste and complex hydrogeology, effectiveness becomes the key aspect. Current waste in the groundwater will remain for years, decades, or even longer. DOE, as per DOE Orders, should resume monitoring off-site impacts and in places where contamination is likely to migrate. Ambient sampling of some extent would too be beneficial in maintaining an off-site surveillance of condition and establishing background conditions.

State oversight should continue to allocate the proper resources to the task of independent monitoring of groundwater in and around the ORR in order to assure the public that all necessary and reasonable steps are being taken to insure the health and safety of the people and environment of the Oak Ridge area.

Proper monitoring should consist of controlled buffer areas combined with vigilant assessment of changes in the groundwater conditions. Such action will be necessary to provide protection from exposure to waste products in the groundwater from DOE operations both legacy and current. Further minimization of exposure could be accomplished by removal of waste instead of trying to hydrologically isolate them under caps. Administrative protections such as deed notices will always be a needed protection to prevent contaminated groundwater from either being directly used or to prevent plumes from being mobilized in conduit flow groundwater systems. Given the nature and extent of contaminated groundwater on the ORR the monitoring of groundwater will be a permanent activity. Accurate understanding of groundwater systems is needed to reduce the risk of potential groundwater exposure.

To accomplish this DOE will need to create a map of groundwater behavior on the ORR. Modeling does not work in environments dominated by turbulent flow and should be considered a diversion from the needed activities to protect the public and the environment. Further, those charged with oversight will have to continue to allocate appropriate resources to encourage the DOE to properly address the problem of contaminated groundwater on the ORR.

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Appendix

Appendix 1 Groundwater Results						
Identification	**Date**	**Parameter Group**	**PARAMETER**	**Result**	**Units**	**Rad Error/MDL**
Bear Creek Km 4.78	03/24/04	Alpha	Gross Alpha	7.5	pCi/l	2.5
	03/24/04	Beta	Gross Beta	4.3	pCi/l	1.8
	03/24/04	Gamma	Bi-214	20.2	pCi/l	3.5
	03/24/04	Gamma	Pb-214	25.8	pCi/l	3.8
	10/26/04	Alpha	Gross Alpha	19.6	pCi/l	5.4
	10/26/04	Beta	Gross Beta	15.2	pCi/l	3.9
	10/26/04	Gamma	Bi-214	29.4	pCi/l	5.1
	10/26/04		Pb-214	27.9	pCi/l	4.3
Bear Creek @ SS-6 Sp.	03/31/04	Alpha	Gross Alpha	19.5	pCi/l	4.2
	03/31/04	Beta	Gross Beta	24.8	pCi/l	3.4
	03/31/04	Gamma	NDA		pCi/l	
Bootlegger Sp.	11/16/04	Alpha	Gross Alpha	0.8	pCi/l	2.2
	11/16/04	Beta	Gross Beta	1.2	pCi/l	2.6
	11/16/04	Gamma	Pb-214	14.8	pCi/l	4.0
	11/16/04	Gamma	Bi-214	22.4	pCi/l	4.2
	11/16/04	TCL Volatiles	TCL Volatiles	U	ug/l	
	07/08/04	TCL Volatiles	cis-1,2,-Dichloroethane	2.6	ug/l	
	07/08/04	TCL Volatiles	1,1-Dichloroethane	1.6	ug/l	
	07/08/04	TCL Volatiles	1,1,1-Trichloroethane	1.6	ug/l	
	07/08/04	TCL Volatiles	Tetrachloroethene	2.6	ug/l	
	07/08/04	Alpha	Gross Alpha	-1.3	pCi/l	2.5
	07/08/04	Beta	Gross Beta	1.2	pCi/l	2.7
	07/08/04	Gamma	Pb-214	119.6	pCi/l	6.4
	07/08/04	Gamma	Bi-214	114.8	pCi/l	6.7
	07/08/04	H-3	Tritium	182.0	pCi/l	163.0
	07/08/04	Tc-99	Tc-99	2.9	pCi/l	3.6
	08/16/04	TCL Volatiles	cis-1,2,-Dichloroethane	3.0	ug/l	
	08/16/04	TCL Volatiles	1,1,1-Trichloroethane	1.0	ug/l	
	08/16/04	Alpha	Gross Alpha	2.0	pCi/l	2.0
	08/16/04	Beta	Gross Beta	0.5	pCi/l	1.1
	08/16/04	Gamma	Pb-214	196.0	pCi/l	8.4
	08/16/04	Gamma	Bi-214	193.6	pCi/l	8.8
	08/16/04	H-3	Tritium	195.0	pCi/l	175.0
	08/16/04	Tc-99	Tc-99	1.1	pCi/l	1.9

Identification	Date	Parameter Group	PARAMETER	Result	Units	Rad Error/MDL
	11/16/04	TCL Volatiles	TCL Volatiles	U	ug/l	
Burns Cem.	11/16/04	Alpha	Gross Alpha	1.5	pCi/l	1.7
	11/16/04	Beta	Gross Beta	0.8	pCi/l	2.4
	11/16/04	Gamma	Bi-214	15.9	pCi/l	3.7
	11/16/04	Gamma	Pb-214	13.5	pCi/l	39.0
Cabin Sp.	12/02/04	TCL Volatiles	Trichlorofluoromethane	1.0	ug/l	
	12/02/04	Gen. Inorganics	Alkalinity, as CaCO3	98.0	mg/l	1.0
	12/02/04		Boron	279.0	µg/L	200.0
	12/02/04		Chloride	2.0	mg/l	1.0
	12/02/04		Conductivity	207.0	Umho	0.5
	12/02/04		pH	7.0	pH Units	
	12/02/04		Residue, dissolved	112.0	mg/l	10.0
	12/02/04		Residue, suspended	U	mg/l	10.0
	12/02/04		Residue, Total	132.0	mg/l	10.0
	12/02/04		Sulfate	9.0	mg/l	2.0
	12/02/04	Nutrients	Nitrogen, Ammonia	0.05	mg/l	0.0
	12/02/04		Nitrogen, NO_3&NO_2	0.11	mg/l	0.0
	12/02/04		Nitrogen, Tot. Kjeldahl	0.24	mg/l	0.1
	12/02/04		Phosphorus, Total	U	mg/l	0.0
	12/02/04	Metals	Arsenic	U	µg/L	1.0
	12/02/04		Cadmium	U	µg/L	1.0
	12/02/04		Calcium	17.7	mg/l	0.0
	12/02/04		Chromium	U	µg/L	1.0
	12/04/04		Cobalt	U	µg/L	10.0
	12/02/04		Iron	78.0	µg/L	25.0
	12/0/204		Lead	U	µg/L	1.0
	12/02/04		Magnesium	13.1	mg/l	0.0
	12/02/04		Manganese	9.0	µg/L	5.0
	12/02/04		Mercury	U	µg/L	0.2
	12/02/04		Nickel	U	µg/L	10.0
	12/02/04		Potassium	0.9	mg/l	0.0
	12/02/04		Selenium	U	µg/L	2.0
	12/02/04		Sodium	1.0	mg/l	0.1
	12/02/04		Thallium	U	µg/L	2.0
	12/02/04		Zinc	2.0	µg/L	1.0

Identification	Date	Parameter Group	PARAMETER	Result	Units	Rad Error/MDL
	12/02/04	Alpha	Gross Alpha	0.7	pCi/l	2.1
	12/02/04	Beta	Gross Beta	3.8	pCi/l	2.7
	12/02/04	Gamma	Bi-214	37.0	pCi/l	4.9
	12/02/04	Gamma	Pb-214	51.2	pCi/l	4.6
Cattail Sp	07/08/04	Alpha	Gross Alpha	2.1	pCi/l	3.7
	07/08/04	Beta	Gross Beta	2.6	pCi/l	2.8
	07/08/04	Gamma	Pb-214	192.4	pCi/l	8.2
	07/08/04	Gamma	Bi-214	190.6	pCi/l	8.8
	07/08/04	Tritium	H-3	0.0	pCi/l	161.0
	07/08/04	Tc-99	Tc-99	2.5	pCi/l	3.6
	07/08/04	TCL Volatiles	Trichloroethene	2.1	µg/L	
	08/16/04	Alpha	Gross Alpha	0.0	pCi/l	1.8
	08/16/04	Beta	Gross Beta	0.3	pCi/l	1.1
	08/16/04	Gamma	Pb-212	11.0	pCi/l	2.7
	08/16/04		Pb-214	104.0	pCi/l	6.4
	08/16/04		Bi-214	105.5	pCi/l	7.1
	08/16/04	Tritium	H-3	0.0	pCi/l	168.0
	08/16/04	Tc-99	Tc-99	1.1	pCi/l	1.9
	08/16/04	TCL Volatiles	TCL Volatiles	U	ug/l	
	11/16/04	TCL Volatiles	TCL Volatiles	U	ppb	
	11/16/04	Alpha	Gross Alpha	2.1	pCi/l	3.3
	11/16/04	Beta	Gross Beta	2.1	pCi/l	2.7
	11/16/04	Gamma	NDA		pCi/l	
Cattail Sp. Dup.	08/16/04	Tritium	H-3	191.0	pCi/l	172.0
	08/16/04	Tc-99	Tc-99	1.1	pCi/l	1.9
Cephus Sp.	12/02/04	TCL Volatiles	TCL Volatiles	U	ug/l	
	12/02/04	Gen. Inorganics	Alkalinity, as CaCO3	106.0	mg/l	1.0
	12/02/04		Boron	U	µg/1	200.0
	12/02/04		Chloride	2.0	mg/l	1.0
	12/02/04		Conductivity	224.0	umho	0.5
	12/02/04		pH	6.7	pH Units	
	12/02/04		Residue, dissolved	126.0	mg/l	10.0
	12/02/04		Residue, suspended	28.0	mg/l	10.0
	12/02/04		Residue, total	179.0	mg/l	10.0
	12/02/04		Sulfate	15.0	mg/l	2.0

Identification	Date	Parameter Group	PARAMETER	Result	Units	Rad Error/MDL
	12/02/04	Alpha	Gross Alpha	0.5	pCi/l	2.1
	12/02/04	Beta	Gross Beta	2.2	pCi/l	2.6
	12/02/04	Gamma	Bi-214	24.2	pCi/l	3.8
	12/02/04	Nutrients	Nitrogen, Ammonia	0.0	mg/1	0.0
	12/02/04		NO3 & NO2	0.2	mg/1	0.0
	12/02/04		Nitrogen, Total Kjeldahl	U	mg/1	0.1
	12/02/04		Phosphorus, Total	U	mg/1	0.0
Cephus Sp. Cont.	12/02/04	Metals	Arsenic	U	µg/L	1.0
	12/02/04		Cadmium	U	µg/L	1.0
	12/02/04		Calcium	38.9	mg/l	0.0
	12/02/04		Chromium	U	µg/L	1.0
	12/02/04		Cobalt	U	µg/L	10.0
	12/02/04		Iron	112.0	µg/L	25.0
	12/02/04		Lead	U	µg/L	1.0
	12/02/04		Magnesium	11.2	mg/l	0.0
	12/02/04		Manganese	33.0	µg/L	5.0
	12/02/04		Mercury	U	µg/1	0.2
	12/02/04		Nickel	U	µg/L	10.0
	12/02/04		Potassium	1.0	mg/l	0.0
	12/02/04		Selenium	U	µg/L	2.0
	12/02/04		Sodium	1.1	mg/l	0.1
	12/02/04		Thallium	U	µg/L	2.0
	12/02/04		Zinc	2.0	µg/L	1.0
Crooked Tree Sp.	11/16/04	Alpha	Gross Alpha	0.6	pCi/l	2.0
	11/16/04	Beta	Gross Beta	1.7	pCi/l	2.6
	11/16/04	Gamma	Gamma Radionuclides	NDA	pCi/l	
Little Dipper	07/08/04	Alpha	Gross Alpha	0.7	pCi/l	2.7
	07/08/04	Beta	Gross Beta	2.2	pCi/l	2.8
	07/08/04	Gamma	Pb-214	81.5	pCi/l	5.6
	07/08/04	Gamma	Bi-214	83.9	pCi/l	6.5
	07/08/04	H-3	Tritium	0.0	pCi/l	160.0
	07/08/04	Tc-99	Tc-99	-0.8	pCi/l	3.6
	08/16/04	Alpha	Gross Alpha	0.0	pCi/l	1.6
	08/16/04	Beta	Gross Beta	0.6	pCi/l	1.1
	08/16/04	Gamma	Pb-214	88.4	pCi/l	5.9

Identification	Date	Parameter Group	PARAMETER	Result	Units	Rad Error/MDL
	08/16/04	Gamma	Bi-214	86.5	pCi/l	6.1
	08/16/04	H-3	Tritium	0.0	pCi/l	168.0
	08/16/04	Tc-99	Tc-99	1.1	pCi/l	1.9
MVMR/Mossy Rock Sp	12/02/04	TCL Volatiles	TCL Volatiles	U	ppb	
	12/02/04	Gen. Inorganics	Alkalinity, as $CaCO_3$	109.0	mg/l	1.0
	12/02/04		Boron	244.0	µg/1	200.0
	12/02/04		Chloride	1.0	mg/l	1.0
	12/02/04		Conductivity	209.0	umho	0.5
	12/02/04		PH	7.1	pH Units	
MVMR/Mossy Rock Sp. cont.	12/02/04	Gen. Inorganics	Residue, suspended	U	mg/l	10.0
	12/02/04		Residue, dissolved	117.0	mg/l	10.0
	12/02/04		Residue total	137.0	mg/l	10.0
	12/02/04		Sulfate	7.0	mg/l	2.0
	12/02/04	Nutrients	Nitrogen, Ammonia	0.02	mg/1	0.0
	12/02/04		Nitrogen, NO_3 & NO_2,	0.38	mg/1	0.0
	12/02/04		Nitrogen, Total Kjeldahl	U	mg/1	0.1
	12/02/04		Phosphorus, Total	U	mg/1	0.1
	12/02/04	Metals	Arsenic	U	ug/L	1.0
	12/02/04		Cadmium	U	ug/L	1.0
	12/02/04		Calcium	35.0	mg/l	0.0
	12/02/04		Chromium	U	ug/L	1.0
	12/02/04		Cobalt	U	ug/L	10.0
	12/02/04		Iron	59.0	ug/L	25.0
	12/02/04		Lead	U	ug/L	1.0
	12/02/04		Magnesium	10.3	mg/l	0.0
	12/02/04		Manganese	7.0	ug/L	5.0
	12/02/04		Nickel	U	ug/L	10.0
	12/02/04		Mercury	U	µg/l	0.2
	12/02/04		Potassium	0.6	mg/l	0.0
	12/02/04		Selenium	U	ug/l	2.0
	12/02/04		Sodium	0.5	mg/l	0.1
	12/02/04		Thallium	U	ug/l	2.0
	12/02/04		Zinc	2.0	ug/l	1.0
	12/02/04	Alpha	Gross Alpha	0.5	pCi/l	2.0
	12/02/04	Beta	Gross Beta	2.9	pCi/l	2.7

Identification	Date	Parameter Group	PARAMETER	Result	Units	Rad Error/MDL
	12/02/04	Gamma	Bi-214	14.4	pCi/l	3.9
	12/02/04	Gamma	Pb-214	11.8	pCi/l	3.3
New Weir	10/26/04	Alpha	Gross Alpha	42.1	pCi/l	8.9
	10/26/04	Beta	Gross Beta	33.5	pCi/l	4.9
	10/26/04	Gamma	Gamma Radionuclides	NDA	pCi/l	
	03/24/04	Alpha	Gross Alpha	23.0	pCi/l	4.5
	03/24/04	Beta	Gross Beta	16.7	pCi/l	3.0
	03/24/04	Gamma	Pb-214	11.2	pCi/l	3.1
	03/24/04	Gamma	Bi-214	15.0	pCi/l	3.3
Raccoon Ck. Sp.	11/16/04	TCL Volatiles	TCL Volatiles	U	ug/l	
	11/16/04	Alpha	Gross Alpha	0.0	pCi/l	1.7
Raccoon Ck. Sp. cont.	11/16/04	Beta	Gross Beta	3.8	pCi/l	2.7
	11/16/04	Gamma	Bi-214	31.1	pCi/l	4.4
	11/16/04	Gamma	Pb-214	14.2	pCi/l	3.5
SNS-1 Sp.	12/02/04	Alpha	Gross Alpha	-0.4	pCi/l	1.9
	12/02/04	Beta	Gross Beta	3.6	pCi/l	2.7
	12/02/04	Gamma	Gamma Radionuclides	NDA	pCi/l	
SNS-4 Sp.	12/02/04	Alpha	Gross Alpha	0.6	pCi/l	1.9
	12/02/04	Beta	Gross Beta	0.4	pCi/l	2.4
	12/02/04	Gamma	Bi-214	39.8	pCi/l	4.2
	12/02/04		Pb-214	35.2	pCi/l	4.3
SS-4 Sp	03/24/04	Alpha	Gross Alpha	25.0	pCi/l	2.2
	03/24/04	Beta	Gross Beta	22.5	pCi/l	1.7
	03/24/04	Gamma	NDA	0.0	pCi/l	0.0
SS-4 Sp. Duplicate	03/24/04	Alpha	Gross Alpha	22.4	pCi/l	4.8
	03/24/04	Beta	Gross Beta	23.7	pCi/l	3.4
SS-5 Sp	10/26/04	TCL Volatiles	TCL Volatiles	U	ug/l	
	10/26/04	Alpha	Gross Alpha	31.8	pCi/l	7.4
	10/26/04	Beta	Gross Beta	18.2	pCi/l	4.1
	10/26/04	Gamma	Bi-214	52.2	pCi/l	5.0
	10/26/04	Gamma	Pb-214	40.7	pCi/l	4.6
	03/24/04	TCL Volatiles	TCL Volatiles		ug/l	
	03/24/04	Alpha	Gross Alpha	4.1	pCi/l	2.2
	03/24/04	Beta	Gross Beta	4.2	pCi/l	1.7
	03/24/04	Gamma	Bi-214	12.4	pCi/l	2.4
	03/24/04	Gamma	Pb-214	12.3	pCi/l	3.6
SS-6 Sp	03/31/04	Alpha	Gross Alpha	0.7	pCi/l	1.4
	03/31/04	Beta	Gross Beta	0.5	pCi/l	1.1

Identification	Date	Parameter Group	PARAMETER	Result	Units	Rad Error/MDL
	03/31/04	Gamma	NDA		pCi/l	
	10/26/04	TCL Volatiles	TCL Volatiles	U	ug/l	
	10/26/04	Alpha	Gross Alpha	6.4	pCi/l	3.8
	10/26/04	Beta	Gross Beta	3.9	pCi/l	3.0
	10/26/04	Gamma	Bi-214	36.4	pCi/l	4.4
	10/26/04		Pb-214	28.4	pCi/l	4.3
SS-7 Sp.	10/26/04	TCL Volatiles	TCL Volatiles	U	ug/l	
	10/26/04	Alpha	Gross Alpha	4.6	pCi/l	3.2
	10/26/04	Beta	Gross Beta	4.9	pCi/l	3.1
	10/26/04	Gamma	Bi-214	63.3	pCi/l	5.9
	10/26/04	Gamma	Pb-214	69.9	pCi/l	5.4
SS-8 Sp	03/24/04	Alpha	Gross Alpha	7.5	pCi/l	2.5
	03/24/05	Beta	Gross Beta	4.3	pCi/l	1.8
	03/24/05	Gamma	Bi-214	25.8	pCi/l	3.8
SS-8 Sp. cont.	03/24/05	Gamma	Pb-214	20.2	pCi/l	3.5
Doug’s Drip Sp.	03/16/2004	TCL Volatiles	m&p Xylene	1.68	µg/l	
	12/02/04	Metals	Mercury	U	µg/l	0.2
	12/02/04	Nutrients	Nitrogen, NO_3 & $NO_{2,}$	0.02	mg/1	
Itchy Sp.	03/16/2004	TCL Volatiles	TCL Volatiles	U	µg/l	
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CHAPTER 4 GROUNDWATER MONITORING

Residential Well Sampling Program

Principal Author: Don Gilmore

Abstract

The goal of this project is to identify potential exit pathways for contamination from the Oak Ridge Reservation (ORR) and to monitor for contamination. The Tennessee Department of Environment and Conservation DOE Oversight Division (the division) is planning to collect water samples for analysis only from new residential wells in the areas offsite from the ORR and those well users requesting sampling. Wells selected for sampling are based upon the potential for groundwater impact from past ORR operations. Analysis information will be provided to the well owners along with assistance, if needed. There were no requests for well sampling by the public. Therefore no sampling was conducted.

Introduction

The primary goal of the Tennessee Department of Environment and Conservation DOE Oversight Division's (the division) residential well sampling program is to determine the impact from past ORR operations on groundwater offsite from the ORR No requests for well sampling were received by the division in 2004. Therefore none were taken. The following discussion relates how and where samples are to be collected and analyzed.

Six years of division monitoring did not identify wells affected by DOE activities. Therefore the division discontinued routine sampling of residential wells. Sampling of residential wells will only be conducted on a written request basis or from newly drilled wells (since 1999) that would provide advantageous locations to monitor for effects from DOE activities. Continued communication to the public offering the opportunity for well water analysis will be maintained through public meetings, the Local Oversight Committee and the Site Specific Advisory Board.

In 1996 the Tennessee Department of Environment and Conservation DOE Oversight Division (TDEC/DOE-O) initiated a residential well sampling program. The purpose of this project was to identify areas of groundwater use for consumption and bathing in the areas off site from the Oak Ridge Reservation (ORR) and determine the environmental impact on groundwater in these areas from past ORR operations. Two major tasks were included in this project: identify residences with drinking water wells and collect groundwater samples for analysis from selected wells. In 1996 and 1997 a house-to-house survey was conducted. In 1999 a notice was written asking for well owners that wished to be in the sampling program to contact this office. This notice was released to the news media.

The user survey was conducted in the area southwest and within two miles of the ORR boundary. This survey was concentrated in areas in line and along geologic strike with the DOE X-10 and Y-12 facilities. A total of 72 residential wells have been identified. Figure 1 shows the location of these wells along with the wells that have been sampled in prior years. A well survey form was completed for each well. It should be noted that the ORR is over 28,000 acres and the City of Oak Ridge and Knox County supply water for a large area north and southeast of the ORR. Typical distances from residential wells to active DOE facilities are two miles. This project was intended to identify potential exit pathways for contamination from the Oak Ridge Reservation (ORR) and to monitor for that contamination. Areas along geologic strike from Y-12, X-10, and the K-25 facility contain wells most likely to be sampled. The current program is focusing on wells that were not available during earlier surveys and well-user requests. Analytical parameters will include radionuclides and selected metals, inorganic analytes and volatile organics. Parameters will vary depending on the potential for off-site groundwater contamination within a given area.

Analysis of past results showed no discernible impact from the activities of DOE on the ORR. No sampling was conducted during the year. The general groundwater quality of the residential wells previously sampled appears to be good. Most homeowners interviewed during the 1996 house-to-house survey and those interviewed since, indicate no problem with groundwater quality. The analytical results from sampling these wells indicated that groundwater quality in these wells is adequate for drinking and household uses.

Methods and Materials

A work plan was prepared for standardizing the collection of groundwater samples from residential wells identified during the house-to-house survey. The locations of the 72 wells identified during this survey were reviewed. From this review, residential wells are selected for sampling. These wells are located generally along a line or transect normal to geologic strike in the area across the Clinch River and southwest of the X-10 and Y-12 facilities. Other wells were selected to test for the effects of DOE across Melton Hill Lake and north of the ORR. See Figure 1 for the location of the wells. These wells were selected along this transect to possibly locate contaminants migrating off site from the ORR via groundwater.

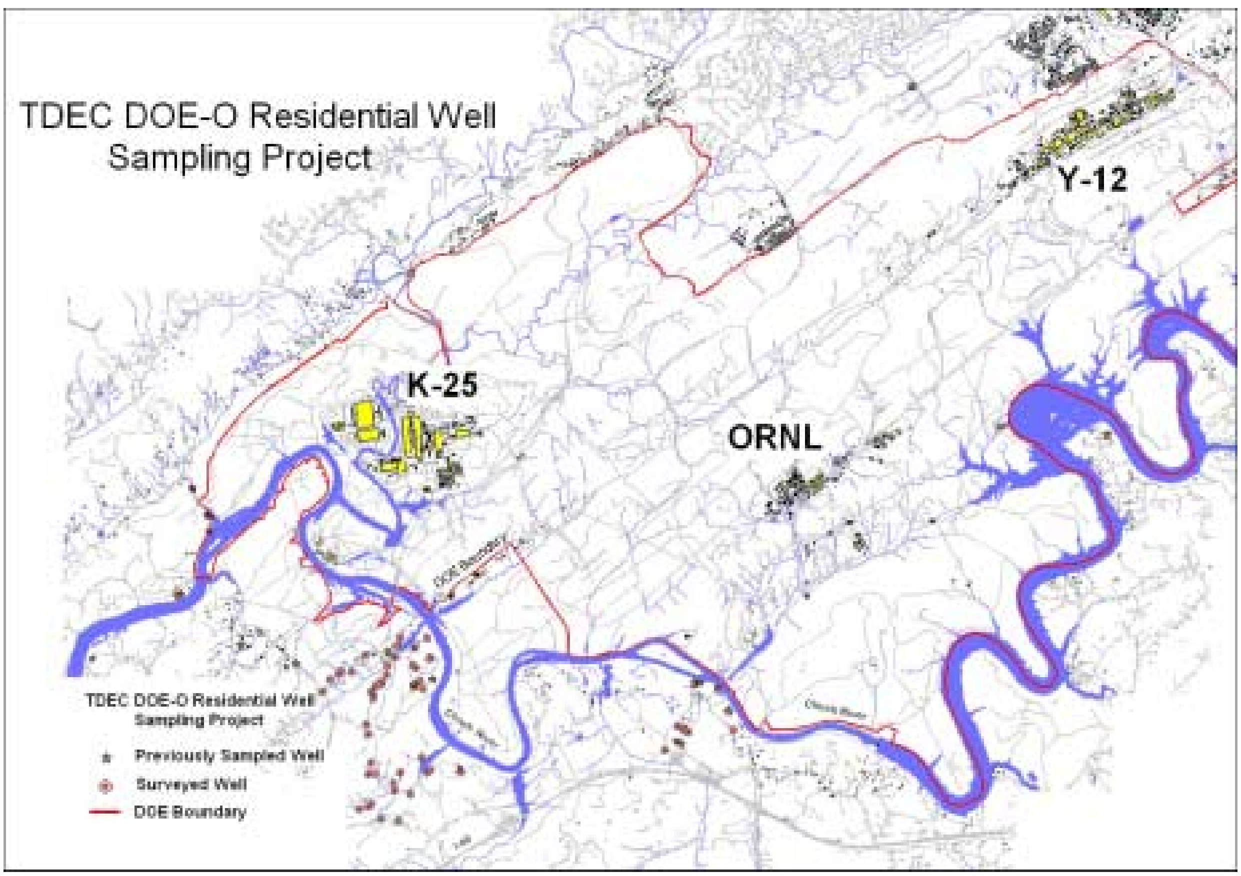

Figure 1. Residential Well Locations

The well samples are analyzed for volatile organic compounds (VOCs), nutrients, radiochemistry, general inorganics, and selected metals. These analytes were selected to identify general groundwater quality in these wells and identify chemical and radiological substances used in past ORR operations. The results were compared to established regulatory maximum contaminant levels (MCLs).

Residential wells are generally sampled from a water tap located outside the property owner's house. Prior to sampling, water was run until pH, temperature, and conductivity readings stabilized. The water quality parameters were constantly checked using portable meters. Water was normally run from the tap for at least 10 minutes before these parameters were stabilized. Water samples were taken immediately after these parameters stabilized.

Samples were collected in laboratory prepared bottles using clean surgeon's gloves. Immediately after sample collection, water samples were placed on ice in a cooler. The time of sample collection and other pertinent information was recorded in a field logbook onsite. Chain of custody forms were filled out from this information. Sample tags were completed and placed on the sample containers immediately after each sample was collected. Water samples were delivered to the State of Tennessee analytical laboratory in Knoxville, Tennessee for analysis.

TDEC/DOE-O sent the analytical results to the owner of each sampled residential well. The analytical results from each well were entered into a computer database, and a cover letter was drafted to be included with the analytical results.

Results and Discussion

The analytical results from sampling residential wells are compared with regulatory MCLs. There are no results this year for these wells as there were no wells sampled.

Conclusion

The general groundwater quality of the residential wells sampled in the past years appears to be good. Most homeowners interviewed during the 1996 house-to-house survey indicated no problem with groundwater quality. Well users, contacted by the division since the survey, have also indicated no concerns about their water quality. The analytical results from sampling these wells indicated that groundwater quality in these wells is adequate for drinking, bathing and household uses.

In past years all data indicated that the sampling results were in a range that could be considered background water quality. The metals that show up are below MCLs but somewhat higher than springs in and around the reservation. The higher metals are most likely due to pumps, wiring, and metal plumbing or well casing. The radiological data is normal for water in the ORR area; essentially background. The spurious volatile organic compound is most likely a lab contaminant or sampling artifact. Sampling of the residential sources of water will continue at the well owner's request under this project. Continuing efforts will be made to advertise.

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CHAPTER 5 RADIOLOGICAL MONITORING

Ambient Radiation Monitoring on the Oak Ridge Reservation Using Environmental Dosimetry (RMO)

Principal Authors: Natalie Pheasant, Gary Riner, Howard Crabtree

Abstract

The Tennessee Department of Environment and Conservation began monitoring ambient radiation levels on the Oak Ridge Reservation in 1995. The program provides conservative estimates of the dose to members of the public from exposure to gamma and neutron radiation attributable to Department of Energy activities on the reservation and baseline values for measuring the need and effectiveness of remedial activities. In this effort, environmental dosimeters have been placed at selected locations on and near the reservation. Results from the dosimeters are compared to background values and the state dose limit for members of the public. While all the doses reported for 2004 at off-site locations were below the dose limit for members of the public (100 mrem/year), several locations that are considered to be potentially accessible to the public had results in excess of the limit. Doses above the limit were common at locations located in access restricted areas of the reservation.

Introduction

Radiation is emitted by various radionuclides that have been produced, stored, and disposed on the Oak Ridge Reservation (ORR). As a consequence of past activities, associated contaminants can be found in ORR facilities and the surrounding environment. In order to assess the risks posed by these contaminants, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Division began monitoring ambient radiation levels on and in the vicinity of the ORR in 1995. In this effort, environmental dosimeters are used to measure the external radiation dose at selected monitoring stations, on and in the vicinity of the ORR. Associated data are compared to background values and the state's primary dose limit for members of the public (100 mrem/year). The program provides:

- conservative estimates of the potential dose to members of the public from exposure to gamma radiation;
- baseline values used to assess the need and effectiveness of remedial actions;
- information necessary to establish trends in gamma radiation emissions;
- information relative to the unplanned release of radioactive contaminants on the ORR.

Methods and Materials

The dosimeters used in the program are obtained from Landauer, Inc., of Glenwood, Illinois. Each dosimeter uses an aluminum oxide photon detector to measure the dose from gamma radiation (minimum reporting value = 1 mrem). At locations where there is a potential for the release of neutron radiation, the dosimeters also contain an allyl diglycol carbonate based neutron detector (minimum reporting value = 10 mrem). Dosimeters that contain the photon detectors alone are collected quarterly and sent to Landauer for processing. Dosimeters that contain both photon and neutron detectors are collected and processed semiannually (to allow more precise neutron measurements). To account for exposures that could be received in transit or storage, control dosimeters of both types are provided with each shipment from the Landauer Company. The control dosimeters are stored at the division's office and returned to Landauer with the associated field deployed dosimeters for processing. Any dose reported for the control dosimeters is subtracted from the results for the field-deployed dosimeters prior to being reported.

Monitoring stations in the program include: operating facilities; locations on the ORR that are potentially accessible to the public; residential areas in Oak Ridge; and sites subject to or undergoing remediation. The approximate locations of the monitoring sites, along with the 2004 dose, are depicted in Figure A1 in the appendix.

As the quarterly results are received, staff prepare a report of the data, which is distributed to DOE, DOE contractors, and other interested parties. At the end of the year, the quarterly results are summed for each location and the resultant annual doses compared to background values and the state of Tennessee's primary dose limit for members of the public (100 mrem/year). Associated data is presented in the attached appendix (Table A1).

Results and Discussion

The dose of radiation received at any given location is dependent on the intensity and the duration of the exposure. For example, an individual standing at a site where the dose rate is 1 mrem/hr would receive a dose of 2 mrem if he stayed at the same spot for 2 hours. If he or she were exposed to the same level of radiation for 8 hours a day for the approximately 220 working days in a year (1,760 hours), the individual would receive a dose of 1,760 mrem in that year. It should be understood the doses reported in the division's Ambient Radiation Monitoring Programs are based on the exposure an individual would receive if he or she remained at the monitoring station 24 hours a day for one year (8,760 hours). Since this is very unlikely to be the actual case, the doses reported should be viewed as conservative estimates of the maximum dose an individual would receive at each location.

In the past, the division relied on the measurement of gamma radiation to estimate the radiation doses at the various monitoring stations. While gamma radiation is expected to be the major contributor to external exposures, an additional dose from neutron radiation is expected at several of the locations monitored, for example, the uranium hexafluoride cylinder storage yards located at the East Tennessee Technology Park (ETTP). In 2000, staff began placing neutron dosimeters at monitoring stations where the presence of neutron radiation was a possibility. Results from these dosimeters have been somewhat erratic, but indicative of a measurable neutron flux at several of the locations. Where a neutron dose was reported in the data, it has been incorporate into the total dose for the year reported in Figure A1 and Table A1.

The monitoring locations and associated results for the program can be roughly organized into three categories: (1) stations located off the ORR; (2) sites on the ORR that are to some degree accessible to the public; and (3) locations within access-controlled areas of the reservation.

Stations off the ORR

The doses reported for monitoring stations off the reservation (e.g., residential areas) were all well below the 100 mrem dose limit for members of the public and to a large degree below the detection capabilities of the environmental dosimeters (1 mrem).

Stations Potentially Accessible to the Public

State regulations define a member of the public as *any* individual, except those receiving an occupational dose of radiation. An occupational dose is a dose of radiation occurring during employment to an individual assigned duties involving exposure to sources of radiation. The regulations go on to limit the dose to members of the public to 100 mrem/year and the release of radiation to unrestricted areas to no more than two mrem in any one-hour period. In this context, a restricted area is defined as an area with access limited for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials.

The Atomic Energy Act exempts DOE from outside regulation of radiological materials at its facilities and delegates to DOE the responsibility of regulating these materials in a manner protective of public health and the environment. Since access to the reservation has been predominately restricted to employees of DOE or their contractors in the past, locations within the fenced areas of the reservation have traditionally been viewed as inaccessible to the general public. With the reindustrialization and revitalization of portions of the reservation, there has been an influx of workers employed by businesses not directly associated with DOE operations. If these individuals are considered members of the general public, several of the sites within the boundaries of the ORR become problematic. Under current conditions, a number of locations exist on the reservation that present radiological hazards and are potentially accessible to workers not employed by DOE or their contractors.

At ETTP, relatively high doses of radiation have routinely been measured in the vicinity of the K-1420 Building (780 mrem) and the uranium hexafluoride (UF_6) cylinder storage yards. For example, dose measurements taken at the cylinder yards in 2004 ranged from 47 to 4,044 mrem. Two of the monitoring stations, station 12 (270 mrem) and Station 51 (1,377 mrem), are located on a fence that separates the K-1066-E Storage Yard from the Poplar Creek area, making it accessible from outside the facility boundary. The fence at the K-1066-K cylinder storage yard (Station 53) is easily accessible and had one of highest doses reported in the program for 2004, 4,044 mrem. Conditions are expected to improve as a consequence of a consent order DOE and TDEC entered into in 1999 requiring the removal of depleted uranium hexafluoride from ETTP by December 31, 2009. In 2004, DOE began shipping these cylinders to the Portsmouth Gaseous Diffusion Plant, where the material is to be converted into a form more suitable for use and / or disposal.

The situation at ORNL is somewhat different: two parcels of land adjacent to the main campus have been deeded to organizations outside of DOE; buildings are being constructed using private funds; and facilities are occupied by non-DOE contractors (2003, ORAU). Access to the site is restricted for security purposes, but admittance is allowed with the appropriate visitor's pass. Within the security boundary, certain areas have been designated as radiation areas for safety, although, the doses measured at the boundary of some of these areas have been relatively high. Locations of concern in 2004 included: The ORNL Coal Yard Environmental Restoration Storage Area (1,953 mrem for one quarter), White Oak Creek Weir at Lagoon Road (244 mrem), ORNL Molten Salt Reactor (853 mrem), and a hot spot found on Haw Ridge (182 mrem).

Of particular interest is the Coal Yard Environmental Restoration Storage Area. Wastes stored here included sludge excavated from the 3513 Waste Holding Basin and the 3524 Equalization

Basin. These wastes contained high levels of cesium-137, along with various other radionuclides including transuranics (Bechtel, 1992). As part of the Surface Impoundments Remedial Action, the sludge taken from the basins was mixed with cement, formed into large concrete monoliths, and stored at various locations across the ORNL campus.

In 2002, staff placed a continuous exposure rate monitor at the boundary of the Environmental Restoration Coal Yard Storage Area near where some of the monoliths had been stored. The measurements taken in December of 2002 averaged approximately 1.7 mrem/hour (1740 μR/hr), which approaches the state's dose limit for unrestricted areas (2 mrem in any one-hour period). Even though the sediments were removed for disposal at the Environmental Management Waste Management Facility (EMWMF) during the quarterly monitoring period, the dose reported for an environmental dosimeter placed at the location was 2,388 mrem (the highest dose reported that quarter). In the absence of the sludge, the dose fell to 16 mrem the following quarter.

The boundary of the radiation area was subsequently reduced to the size necessary to surround contaminated materials from the Corehole 8 Remedial Action and the dosimeter was repositioned in last quarter of 2003. The dose reported for that quarter was 2,669 mrem. During the first quarter of 2004, this waste was also removed and disposed in the EMWMF. While at the site for only part of the quarter, the dose reported was 1,953 mrem.

<u>Stations within Access Controlled Areas of the Reservation</u>

While conditions could change, other sites monitored that reported results appreciably above the primary dose limit for members of the public are located within access controlled areas of the reservation. These sites are subject to remediation in accordance with the provisions of CERCLA and the Federal Facility Agreement (FFA) for the ORR. While it is beyond the scope of this report to address each of these sites individually, several merit comment.

The Cesium Forest [Station 32 (14,801 mrem)]: The highest dose reported for 2004 was from a dosimeter that has been placed on a tulip poplar tree (Station 32) in ORNL's Cesium Forest. In 1962, a group of trees at this location were injected with a total of 360 millicuries of cesium-137, as part of a study on the isotope's behavior in a forest ecosystem (Witkamp, 1964). Based on the dosimetry results, it appears a significant amount of the cesium remains in the trees and local environment. The dose reported for 2004 was 14,801 mrem, which is a little lower than the dose reported for 2003 (15,325 mrem).

Other access controlled sites with a dose greater than 100 mrem in 2004 include Station 35 at ORNL near the confluence of White Oak Creek and Melton Branch (734 mrem), Station 87 at ORNL's SWASA 5 disposal area (399 mrem), Station 56 at ORNL's Old Hydrofracture Pond (295 mrem), and Station 46 at ORNL's Homogeneous Reactor Site (152 mrem). These sites appear unlikely to be accessed by a member of the public under current conditions. All except Station 32 in the Cesium Forest fall below the limits for an adult worker monitored with personnel dosimetry (5000 mrem/year).

Conclusion

The monitoring of radiation using environmental dosimeters has proven to be a relatively economic and effective method of estimating ambient gamma radiation levels on and in the vicinity of the ORR. Doses reported for 2004 at off-site locations were all below the state limit for members of the public. Several locations on the reservation considered potentially accessible to the public exhibited results in excess of the primary dose limit. These sites included uranium hexafluoride cylinder storage yards at ETTP and an Environmental Restoration Storage Areas at ORNL. As in the past, various sites located in restricted areas of the reservation exhibited annual doses in excess of the primary dose limit. These sites are subject to remediation in accordance with provisions specified in CERCLA and the FFA.

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APPENDIX: LOCATION MAP AND TABLE OF RESULTS FROM TDEC MONITORING ON THE OAK RIDGE RESERVATION USING ENVIRONMENTAL DOSIMETERS

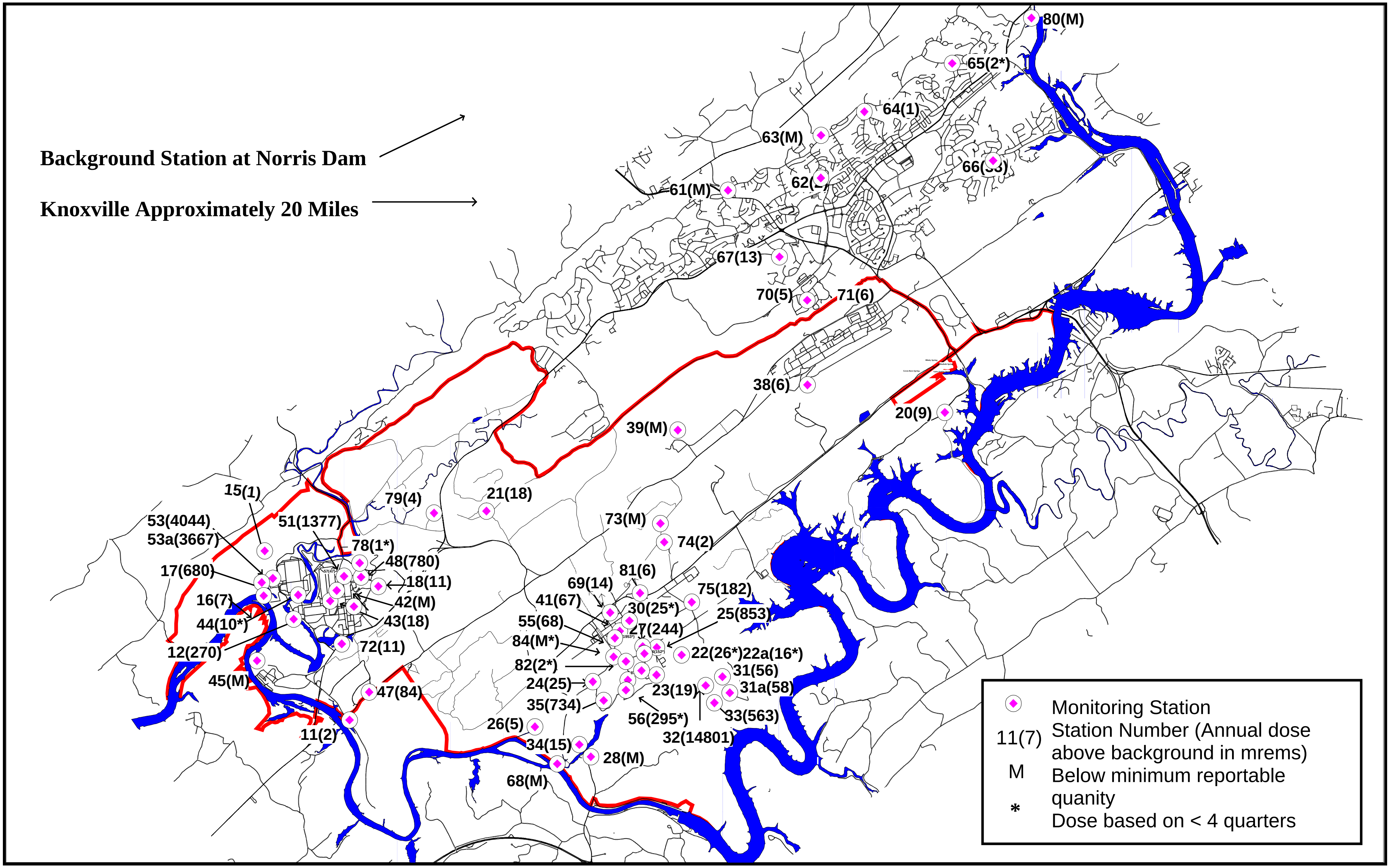

Figure A1: Approximate Location TDEC Environmental Dosimeters on the Oak Ridge Reservation

Table A1: 2004 Results from TDEC monitoring on the Oak Ridge Reservation using Environmental Dosimeters

Station # (Dosimeter)	Location *Optically Stimulated Luminescent Dosimeter (OSLs) are reported quarterly*	Type of Radiation	Dose Reported for 2004 in mrems M = Below Minimum Reportable Quantity				2004 Total Dose	*2003 Total Dose*
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
9. (OSL)	Off-site Norris Dam Air Monitoring Station (Background)	Gamma	7	M	M	M	7	*7*
11. (OSL)	ETTP Grassy Creek Embayment on the Clinch River	Gamma	2	M	M	M	2	*11*
12. (Neutron)	ETTP UF_6 Cylinder Storage Yard K-1066-E	Neutron	M		M		270	*194*
		Gamma	139		131			
15. (OSL)	ETTP K-1070-A Burial Ground	Gamma	M	1	M	M	1	*9*
16. (OSL)	ETTP K-901 Pond	Gamma	7	M	M	M	7	*20*
17. (Neutron)	ETTP K-1066-K UF_6 Cylinder Yard (near K-895)	Neutron	M		M		680	*659*
		Gamma	361		319			
18. (OSL)	ETTP TSCA on fence across from Tank Farm	Gamma	6	4	1	M	11	*26*
20. (OSL)	ORNL Freels Bend Entrance	Gamma	7	2	M	M	9	*10*
21. (OSL)	ETTP White Wing Scrap Yard	Gamma	11	3	3	1	18	*36*
22. (OSL)	ORNL High Flux Isotope Reactor	Gamma	10	7	9	Lost	26*	*42*
22a. (OSL)	ORNL High Flux Isotope Reactor (duplicate)	Gamma	8	3	5	Lost	16*	*18**
23. (OSL)	ORNL Solid Waste Storage Area 5	Gamma	7	6	4	2	19	*30*
24. (OSL)	ORNL Building X-7819	Gamma	10	8	6	1	25	*13**
25. (OSL)	ORNL Molten Salt Reactor Experiment	Gamma	267	219	178	189	853	*877*
26. (OSL)	ORNL Cesium Fields	Gamma	4	M	1	M	5	*9*
27. (OSL)	ORNL White Oak Creek Weir @ Lagoon Rd	Gamma	82	63	45	54	244	*282*
28. (OSL)	ORNL White Oak Dam	Gamma	M	M	M	M	M	*15*
30. (OSL)	ORNL X-3513 Impoundment	Gamma	23	2	Lost	M	25*	*1,358*
31. (OSL)	ORNL @ Cesium Forest boundary	Gamma	18	16	11	11	56	*69*
31a. (OSL)	ORNL @ Cesium Forest boundary (duplicate)	Gamma	22	15	9	12	58	*85*
32. (OSL)	ORNL Cesium Forest on tree	Gamma	6,290	2,999	2,609	2,903	14,801**	*15,325***
33. (OSL)	ORNL Cesium Forest Satellite Plot	Gamma	165	143	131	124	563	*637*
34. (OSL)	ORNL SWSA 6 on fence @ Highway 95	Gamma	11	1	3	M	15	*20*
35. (OSL)	ORNL confluence of White Oak Creek & Melton Branch	Gamma	223	198	169	144	734	*839*
38. (OSL)	Y-12 Uranium Oxide Storage Vaults	Gamma	5	1	M	M	6	*48*
39. (OSL)	Y-12 @ back side of Walk In Pits	Gamma	M	M	M	M	M	*12*
41. (OSL)	ORNL North Tank Farm	Gamma	26	21	17	3	67	*258*
42. (OSL)	ETTP east side of the K-1401 Building	Gamma	M	M	M	M	M	*5*
43. (OSL)	ETTP west side of the K-1401 Building	Gamma	11	3	2	2	18	*18*
44. (OSL)	ETTP K-25 Building	Gamma	9	Lost	1	M	10*	*14*

Table A1: 2004 Results from TDEC monitoring on the Oak Ridge Reservation using Environmental Dosimeters (Continued)

Station # (Dosimeter)	Location *Optically Stimulated Luminescent Dosimeter (OSLs) are reported quarterly*	Type of Radiation	Dose Reported for 2004 in mrems M = Below Minimum Reportable Quantity				2004 Total Dose	*2003 Total Dose*
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
45. (OSL)	ETTP K-770 Scrap Yard	Gamma	M	M	M	M	M	3
46. (OSL)	ORNL Homogeneous Reactor Experiment Site	Gamma	Lost	152	Lost	M	152*	390
47. (OSL)	Y-12 Bear Creek Road ~ 2800 feet from Clinch River	Gamma	26	16	26	16	84	105
48. (OSL)	ETTP K-1420 Building	Gamma	226	238	148	168	780	802
51. (Neutron)	ETTP north side of the K-1066-E UF_6 Cylinder Storage Yard	Neutron	M		M		1,377	1,357
		Gamma	774		603			
53. (Neutron)	ETTP southwest corner of the K-1066-K UF_6 Cylinder Storage Yard	Neutron	30		M		4,044	1,889
		Gamma	1,950		2,064			
53a. (Neutron)	ETTP southwest corner of the K-1066-K UF_6 Cylinder Storage Yard (duplicate)	Neutron	M		M		3,667	1,623
		Gamma	1,692		1,975			
55. (OSL)	ORNL SWSA 5 True Waste Trench	Gamma	30	18	14	6	68	241
56. (OSL)	ORNL Old Hydrofracture Pond	Gamma	250	Lost	45	Lost	295*	828
56a. (Neutron)	ORNL Old Hydrofracture Pond (duplicate)	Neutron	Lost		Lost		No data available	781
		Gamma	Lost		Lost			
57. (OSL)	ETTP UF_6 Cylinder Storage Yard K-1066-B	Gamma	29	18	M	M	47	155
61. (OSL)	Off site Temp. #14 Outer & Illinois Ave	Gamma	M	M	M	M	M	3
62. (OSL)	Off site Temp. #15 East Pawley	Gamma	2	M	M	M	2	8
63. (OSL)	Off site Temp. #16 Key Springs Road	Gamma	M	M	M	M	M	4
64. (OSL)	Off site Temp. #17 Cedar Hill Greenway	Gamma	1	M	M	M	1	5
65. (OSL)	Off site Temp. #18 California Ave.	Gamma	2	Lost	M	M	2*	2*
66. (OSL)	Off site Temp. #19 Emory Valley Greenway	Gamma	12	9	7	5	33	50
67. (OSL)	Off site Temp. #20 West Vanderbilt	Gamma	10	M	2	1	13	14
68. (OSL)	ORNL White Oak Creek @ Coffer Dam	Gamma	M	M	M	M	M	3
69. (OSL)	ORNL Graphite Reactor	Gamma	7	7	M	M	14	25
70. (OSL)	Off site Scarboro Perimeter Air Monitoring Station	Gamma	2	2	1	M	5	15
71. (OSL)	Y-12 East Perimeter Air Monitoring Station	Gamma	5	1	M	M	6	13
72. (OSL)	ETTP Visitors Center	Gamma	3	7	1	M	11	32
73. (OSL)	ORNL Temp. #3: Spallation Neutron Source (north side)	Gamma	M	M	M	M	M	3*
74. (OSL)	ORNL Temp. #4: Spallation Neutron Source (south side)	Gamma	2	M	M	M	2	3*
75. (OSL)	ORNL Temp #5: hot spot on Haw Ridge	Gamma	57	45	43	37	182	215
78. (OSL)	ETTP Temp. #11: ED3 Quarry at Blair Road	Gamma	1	M	Lost	M	1*	10
79. (OSL)	ETTP Temp. # 12: ED1 on pole	Gamma	4	M	M	M	4	10

Table A1: 2004 Results from TDEC monitoring on the Oak Ridge Reservation using Environmental Dosimeters (Continued)

Station # (Dosimeter)	Location *Optically Stimulated Luminescent Dosimeter (OSLs) are reported quarterly*	Type of Radiation	Dose Reported for 2004 in mrems M = Below Minimum Reportable Quantity				2004 Total Dose	*2003 Total Dose*
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
80. (OSL)	Off site Temp. #13: Elza Gate	Gamma	1	M	M	M	1	4
81. (OSL)	ORNL visitors center	Gamma	5	1	M	M	6	6
82. (OSL)	ORNL Wag 3	Gamma	2	M	Discontinued		2*	22
84. (OSL)	ORNL Temp. #2 Wag 3	Gamma	M	M	Discontinued		M*	37
86. (OSL)	Off site Fort Loudoun Dam Air Monitoring Station (Background)	Gamma	M	M	M	M	M	5
86a. (Neutron)	Off site Loudoun Dam Air Monitoring Station (Background)	Neutron	M		M		8	8
		Gamma	8		M			
87. (Neutron)	ORNL SWSA 5	Neutron	M		M		399	341
		Gamma	205		194			
89 (OSL)	ORNL Cole Yard Storage Area (Core Hole 8 material).	Gamma	1,953	Discontinued			1953*	2,669*

Notes: Two types of dosimeters are used in the program, optically stimulated luminescent dosimeters (OSLs) and neutron dosimeters. The OSLs measure the dose from gamma radiation, which is considered sufficient for most of the monitoring stations. The neutron dosimeters, which have been placed at selected locations, measure the dose from neutrons in addition to the gamma radiation. The OSLs are reported quarterly; the neutron dosimeters are reported semiannually. At the locations where the neutron dosimeters have been deployed, the total dose is the sum of the doses reported for neutron and gamma radiation.

The primary dose limit for members of the public specified in both DOE Orders and 10 CFR Part 20 (Standards for Protection Against Radiation) is 100 mrem/year total effective dose equivalent exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/yr.

To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division office and returned to the vender for processing along with the associated field deployed dosimeters. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division offices, is subtracted from the exposure reported above for the field deployed dosimeters.

M = Below minimum reportable quantity.
Lost – The dosimeter could not be found at the monitoring station.
*The dose reported for this station was based on the sum of less than four quarters of data.
** #32 “Cesium Forest on Tree” was repositioned at the beginning of the third quarter 2003 resulting in increased reading.

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CHAPTER 5 RADIOLOGICAL MONITORING

Ambient Gamma Radiation Monitoring of the Uranium Hexafluoride (UF6) Cylinder Yards at the East Tennessee Technology Park

Principle Author: Robert Storms

Abstract

The Tennessee Department of Environment and Conservation Department of Energy Oversight Division (the division) in cooperation with the Department of Energy (DOE) and the Bechtel Jacobs Company is conducting a radiation dose rate survey of the East Tennessee Technology Park's (ETTP) Uranium Hexafluoride (UF_6) cylinder storage yards. Dose rate measurements are taken at the Perimeter fence lines using Landauer® Luxel® optically stimulated luminescence (Aluminum Oxide) dosimeters. Monitoring of ambient gamma levels at the UF_6 cylinder storage yards began in April 1999 and has continued to date. The data gathered is being used to determine if areas monitored have exceeded state and/or federal regulatory limits for exposure to members of the public. This data is also being used to determine if environmental concerns are warranted and what, if any, remediation actions are necessary before this property is free released and/or prior to occupation by companies during the planned reindustrialization of the ETTP site. In this study period from January 2004 to January 2005, dose rates in excess of the 100-mrem/yr state/federal exposure limit were observed at four of the five monitored cylinder yards. The K-1066 B Yard was emptied out mid-year, causing the total yearly dose rate to drop. Specific location data has been obtained for all stations with the use of GPS instrumentation. This specific location data, along with its corresponding radiological data, will be incorporated into the MapInfo computer program. With this, the user has the ability to locate an individual monitoring point and view its radiological history.

Introduction

During the development and operation of the gaseous diffusion uranium enrichment process, containers, support equipment, and support facilities were designed, constructed, and used to store, transport, and process the depleted UF_6. After a significant inventory was produced, outdoor storage facilities (i.e., cylinder yards) evolved. Today, the Bechtel Jacobs Company operates the six ETTP UF_6 cylinder storage yards for the DOE. They are used for the temporary and long-term storage of UF_6 cylinders. The goal of the DOE-O UF_6 cylinder yard dose assessment program is to evaluate the level at which the public is protected from radiation doses emitted from the cylinder yards. This is especially important since DOE's mission is the continual transformation of ETTP into a commercial industrial park.

Materials and Methods

Dosimeters measure the dose from exposure to gamma radiation over time. The division's cylinder yard monitoring is performed using one type of dosimeter, Aluminum Oxide. They are obtained from Landauer®, Inc., Glenwood, Illinois. Aluminum Oxide dosimeters (minimum reporting value of 1 mrem) are generally placed in areas where exposures are expected to be significantly higher than background. The dosimeters are collected by division staff and shipped to Landauer® for processing. To account for exposures that may be received in transit or storage, control dosimeters are included in each shipment from the Landauer® Company. The control dosimeters are stored in a shielded container, at the division office, and returned to Landauer® with the field-deployed dosimeters for processing. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division office (761 Emory Valley Road, Oak Ridge, Tennessee) is subtracted from the exposure reported for the field deployed dosimeters by Landauer. Annually, the quarterly exposures (minus the exposure obtained from the control dosimeter) are summed for each location. The resultant annual dose is compared to the state/DOE primary dose limit for members of the public (100 mrem/yr exposure).

Discussion and Results

The division's Ambient Gamma Radiation Monitoring program has determined that there is an elevated exposure potential to the public at four of the five monitored cylinder yards, with the removal of all cylinders from the K-1066 B-yard. 2004 monitoring results at these yards, the total adjusted accumulated annual dose, as measured by dosimeter, has ranged from a low of 4 mrem at the K-1066-B to a high of 7186 mrem at the K-1066-K yard. Both of these values are down from last year. Within this range, there are numerous elevated data points that are shown in Tables 1-5. These results are compared with the state/DOE primary dose limit for members of the public (100 mrem/yr total exposure). The mapping and recording of dose rate data will ensure that workers/non-DOE workers under ETTP's reindustrialization plan and the public will be knowledgeable of and protected from the cylinder yard's radiation source.

The following ETTP cylinder yards under the dosimeter project are: K-1066-K, K-1066-E, K-1066-J, K-1066-B, K-1066-L.

Current and future plans by ETTP to prepare cylinders for yard-to-yard movement and off-site shipment will necessitate "shuffling" cylinders between various yards. Due to this activity, there have been some wide variances in the dosimeter readings from quarter to quarter. These have all been checked and correlated with redistribution activity of the cylinders. Plans are in place for 2005 to evaluate the current positions of TLDs and relocate those necessary to insure perimeter coverage of the yards due to recent redistribution of the cylinders. K-1066-F yard is not being monitored due to the fact it does not have an outside perimeter fence that could be accessed by the public.

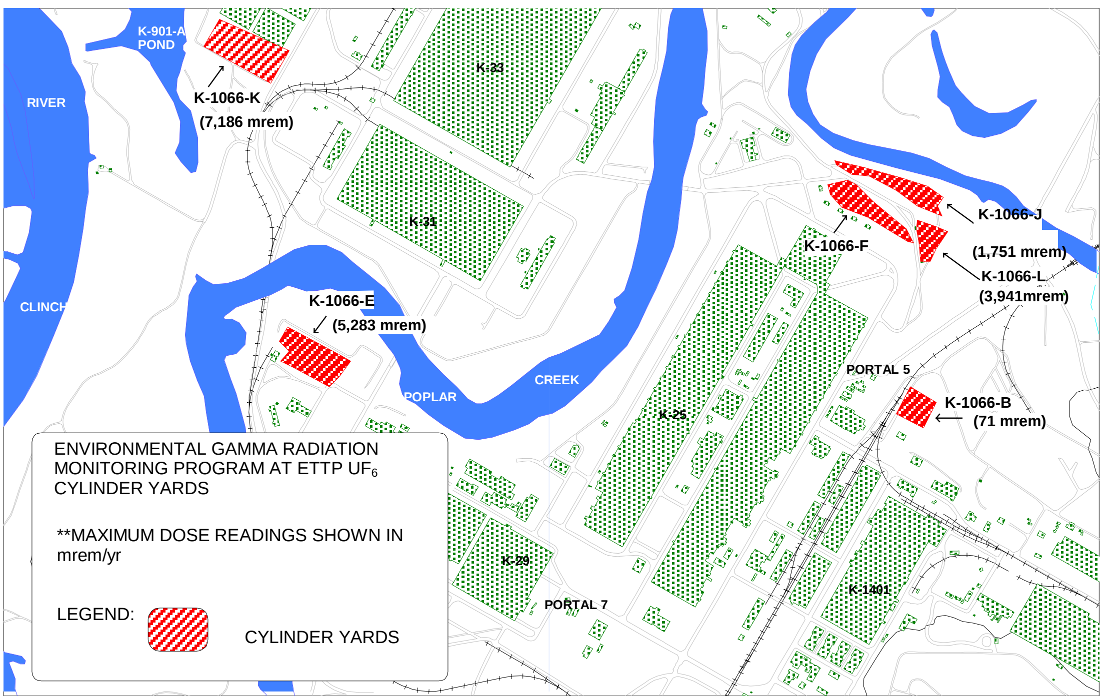

Figure 1: Map of ETTP showing location of cylinder yards.

Table 1: Results from Dosimeters Deployed at ETTP UF_6 Cylinder Yards.

K-1066-K Yard

	Period 1 (01/27/04 - 04/20/04) (84 Day Exposure)	**Period 2** (04/21/04 - 07/20/04) (91 Day Exposure)	**Period 3** (07/21/04 - 10/20/04) (91 Day Exposure)	**Period 4** (10/21/04- 01/20/05) (92 Day Exposure)	Total Accumulated Dose Equivalent: 358 days	Total Adjusted Dose to 365 days
Dosimeter Number	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	mrem	mrem
1	38	45	36	32	151	154
2	206	119	104	124	553	564
3	505	380	330	408	1623	1655
4	1064	1214	1009	1107	4394	4480
5	343	199	178	171	891	908
6	224	327	234	285	1070	1091
7	292	610	461	479	1842	1878
8	287	453	357	411	1508	1538
9	539	637	518	514	2208	2251
10	236	325	205	239	1005	1025
11	137	168	135	130	570	581
12	382	462	350	346	1540	1570
13	1424	1659	1403	1438	5924	6040
14	1579	1833	1481	1667	6560	6689
15	1293	1510	1367	1376	5546	5655
16	995	1158	923	963	4039	4118
17	413	515	402	432	1762	1797
18	1042	1298	1266	1062	4668	4759
19	1600	2086	1603	1759	7048	7186
20	1277	1631	1251	1162	5321	5425
21	153	143	114	126	536	547
22	340	415	340	339	1434	1462

*The primary dose limit for members of the public specified in both DOE Order 5400.5 (Radiation Protection of the Public and the Environment) and 10 CFR Part 20 (Standards for Protection against Radiation) is 100 mrem/yr total effective dose equivalent, exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/yr.

* To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division office, in a shielded container, and returned to the vender for processing along with the associated field deployed dosimeters. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division office, is subtracted from the exposure reported above for the field deployed dosimeters by Landauer.

M= Below minimum reportable quantity.

Table 2: Results from Dosimeters Deployed at ETTP UF_6 Cylinder Yards.

K1066-E Yard

	Period 1 (01/28/04 - 04/21/04) (84 Day Exposure)	**Period 2** (04/22/04 - 07/21/04) (91 Day Exposure)	**Period 3** (07/22/04 - 10/20/04) (90 Day Exposure)	**Period 4** (10/21/04 – 01/20/05) (92 Day Exposure)	Total Accumulated Dose Equivalent: 357 days	Total Adjusted Dose to 365 days
Dosimeter Number	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	mrem	mrem
23	903	1181	912	270	3266	3338
24	549	596	368	410	1923	1965
25	102	123	103	234	562	574
26	63	74	61	179	377	385
27	1141	1437	1234	1357	5169	5283
28	1111	1137	932	1042	4222	4315
29	1015	1146	1026	1186	4373	4469
30	665	832	617	837	2951	3016
31	876	924	823	829	3452	3528
32	1147	1255	1221	1271	4894	5002
33	1088	1330	1180	1167	4765	4870
34	302	200	163	171	836	854
35	154	174	140	152	620	634
36	308	348	291	283	1230	1257
37	272	289	195	239	995	1017
38	191	161	138	175	665	680
39	157	149	130	138	574	587
76	38	41	27	36	142	145
77	53	61	43	59	216	221
78	36	51	31	40	158	161
79	257	296	230	243	1026	1049
80	363	420	331	354	1468	1500
81	372	420	353	316	1461	1493
82	316	389	292	311	1308	1337
83	280	343	219	270	1112	1136
84	168	195	164	164	691	706

* The primary dose limit for members of the public specified in both DOE Order 5400.5 (Radiation Protection of the Public and the Environment) and 10 CFR Part 20 (Standards for Protection against Radiation) is 100 mrem/yr total effective dose equivalent, exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/yr.

* To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division office, in a shielded container, and returned to the vender for processing along with the associated field deployed dosimeters. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division office, is subtracted from the exposure reported above for the field deployed dosimeters by Landauer.

Table 3: Results from dosimeters deployed at ETTP UF_6 Cylinder Yards.

K1066-J Yard

	Period 1 (01/28/04 - 04/21/04) (84 Day Exposure)	**Period 2** (04/22/04 - 07/21/04) (91 Day Exposure)	**Period 3** (07/22/04 - 10/20/04) (90 Day Exposure)	**Period 4** (10/21/04 - 01/20/05) (92 Day Exposure)	Total Accumulated Dose Equivalent: 357 days	Total Adjusted Dose to 365 days
Dosimeter Number	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	mrem	mrem
40	13	20	M	M	33	34
41	9	12	M	M	21	21
42	12	27	7	M	46	47
43	24	21	M	M	45	46
44	40	38	M	M	78	80
45	184	120	56	6	366	374
46	55	62	28	M	145	148
47	90	88	7	M	185	189
48	804	701	208	M	1713	1751
49	406	214 ^	38	M	444	454
50	415	311	40	5	771	788
51	383	354	47	6	790	807
52	284	373	62	5	724	740
53	130	345	52	M	527	539
54	77	83	40	M	200	204
55	37	35	M	2	74	76
85	7	13	M	M	20	20
86	17	18	M	M	35	36
87	30	25	M	M	55	56
88	58	50	6	M	114	117
89	96	73	18	M	187	191
90	70	58	11	M	139	142
91	65	67	4	M	136	139
92	58	46	M	M	104	106

* The primary dose limit for members of the public specified in both DOE Order 5400.5 (Radiation Protection of the Public and the Environment) and 10 CFR Part 20 (Standards for Protection against Radiation) is 100 mrem/yr total effective dose equivalent, exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/yr.

* To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division office, in a shielded container, and returned to the vender for processing along with the associated field deployed dosimeters. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division office, is subtracted from the exposure reported above for the field deployed dosimeters by Landauer.

M= Below minimum reportable quantity. (^estimated value)

Table 4: Results from dosimeters deployed at ETTP UF_6 Cylinder Yards.

K1066-B Yard

	Period 1 (01/27/04 - 04/20/04) (84 Day Exposure)	Period 2 (04/21/04 - 07/20/04) (91 Day Exposure)	Period 3 (07/21/04 - 10/20/04) (91 Day Exposure)	Period 4 (10/21/04- 01/20/05) (92 Day Exposure)	Total Accumulated Dose Equivalent: 358 days	Total Adjusted Dose to 365 days
Dosimeter Number	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	mrem	mrem
56	23	9	M	M	32	33
57	40	23	M	M	63	64
58	29	13	M	M	42	43
59	52	18	M	M	70	71
60	32	8	M	M	40	41
61	43	19	M	M	62	63
62	37	19	M	M	56	57
63	33	8	M	M	41	42
64	18	5	M	M	23	23
65	16	6	M	M	22	22
66	11	4	M	M	15	15
67	7	10	M	M	17	17
93	27	24	M	M	51	52
94	20	11	M	M	31	32
95	24	11	M	M	35	36
96	34	8	M	M	42	43
97	9	3	M	M	12	12
98	3	1	M	M	4	4
99	7	5	M	M	12	12
100	9	3	M	M	12	12
101	5	5	M	M	10	10
102	11	6	M	M	17	17
103	6	M	M	M	6	6

* The primary dose limit for members of the public specified in both DOE Order 5400.5 (Radiation Protection of the Public and the Environment) and 10 CFR Part 20 (Standards for Protection against Radiation) is 100 mrem/yr total effective dose equivalent, exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/yr.

* To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division office, in a sealed container, and returned to the vender for processing along with the associated field deployed dosimeters. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division office, is subtracted from the exposure reported above for the field deployed dosimeters by Landauer.

M= Below minimum reportable quantity.

Table 5: Results from Dosimeters Deployed at ETTP UF_6 Cylinder Yards.

K1066-L Yard

	Period 1 (01/28/04 - 04/21/04) (84 Day Exposure)	**Period 2** (04/22/04 - 07/21/04) (91 Day Exposure)	**Period 3** (07/22/04 - 10/20/04) (90 Day Exposure)	**Period 4** (10/21/04-01/20/05) (92 Day Exposure)	Total Accumulated Dose Equivalent: 357 days	Total Adjusted Dose to 365 days
Dosimeter Number	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	mrem	mrem
68	53	58	20	M	131	134
69	65	55	1	M	121	124
70	69	65	3	M	137	140
71	1682	1221	2	M	2905	2969
72	2017	1251	M	M	3268	3340
73	2158	1693	5	M	3856	3941
74	1156	987	M	M	2143	2190
75	891	967	M	M	1858	1899

* The primary dose limit for members of the public specified in both DOE Order 5400.5 (Radiation Protection of the Public and the Environment) and 10 CFR Part 20 (Standards for Protection against Radiation) is 100 mrem/yr total effective dose equivalent, exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/yr.
* To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division office, in a shielded container, and returned to the vender for processing along with the associated field deployed dosimeters. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division office, is subtracted from the exposure reported above for the field deployed dosimeters by Landauer.

M= Below minimum reportable quantity.

Conclusions

The data are showing elevated readings at four of the five cylinder yards. These annual doses are in excess of the state/DOE primary dose limit for members of the public where the public has access. The yards may also produce ten or fifteen percent additional mrems in neutron as well as gamma doses. Neutron dosimetry is being gathered in another division program. Monitoring of the B-yard will discontinue based on the evidence that no substantial readings were found in two quarters of data, after the removal of the UF6 cylinders from the yard.

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CHAPTER 5 RADIOLOGICAL MONITORING

Real Time Ambient Gamma Monitoring of the Oak Ridge Reservation

Principal Authors: Gary Riner, Howard Crabtree

Abstract

In 2004, the Tennessee Department of Environment and Conservation placed gamma exposure rate monitors at a background location (Fort Loudoun Dam), SWASA 5 North (ORNL), Y-12's Industrial Landfill, the 3513 Waste Holding Basin (ORNL), the Environmental Restoration Coal Yard Storage Area (ORNL), and the Environmental Management Waste Management Facility (Bear Creek Valley). Measurements collected from these sites ranged from 1 microroentgen per hour (μR/hr) to 1,720 μR/hr. The highest exposure rates were recorded at the weigh-in station for the Environmental Management Waste Management Facility during delivery of wastes associated with the Corehole 8 remediation at ORNL. While not a DOE requirement, the highest value (1,720 μR/hr) approaches limits specified by State and Nuclear Regulatory Commission regulations requiring their licensees to conduct operations in such a manner that the external dose in any unrestricted area does not exceed 2.0 millirem (approximately 2000 μR) in any one-hour period.

Introduction

The Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division has deployed continuously recording exposure rate monitors on the Oak Ridge Reservation (ORR) since 1996. While the environmental dosimeters used in the division's Ambient Monitoring Program provide the cumulative dose over the time period monitored, the results cannot account for the specific time, duration, and magnitude of fluctuations in the dose rates. Consequently, a series of small releases cannot be distinguished from a single large release, using the dosimeters alone. The continuous exposure rate monitors record gamma radiation levels at short intervals (e.g., one minute), providing an exposure rate profile that can be correlated with activities or changing conditions at a site. The instruments have primarily been used to record exposure rates during remedial activities and to supplement the integrated dose rates provided by the division's environmental dosimetry.

In 2004, the exposure rate monitors were placed at a background station located at Fort Loudoun Dam in Loudon County, the 3513 Waste Holding Basin at Oak Ridge National Laboratory (ORNL); Solid Waste Storage Area (SWSA) 5 North in Melton Valley, the Y-12 Industrial Landfill, the Environmental Restoration Coal Yard Storage Area (ORNL), and the Environmental Management Waste Management Facility (EMWMF) located in Bear Creek Valley near the Y-12 National Security Complex.

Methods and Materials

The exposure rate monitors used in the program are manufactured by Genitron Instruments and marketed under the trade name GammaTRACER.® Each unit contains two Geiger-Mueller tubes, a microprocessor controlled data logger, and lithium batteries sealed in a weather resistant case to protect the internal components. The instruments can be programmed to measure gamma exposure rates from 1 μR/hr to 1 R/hr at predetermined intervals (one minute to two hours). The results reported are the average of the measurements recorded by the two Geiger-Mueller detectors, but data from each detector can be accessed, if needed. Information recorded by the data loggers is downloaded to a computer using an infrared transceiver and associated software. Monitoring in the program focuses on the measurement of exposure rates under conditions where gamma emissions can be expected to fluctuate substantially over relatively short periods and / or there is a potential for the unplanned release of gamma emitting radionuclides to the environment. Candidate monitoring locations include: remedial activities, waste disposal operations, pre and post operational investigations, and emergency response activities. Results recorded by the monitors are compared to background measurements and state radiological standards.

Results and Discussion

The amount of radiation an individual can be exposed to is restricted by state and federal regulations. The primary dose limit for members of the public specified by these regulations is a total effective dose equivalent* of 100 mrem in a year. Since there are no agreed upon levels where exposures to radiation constitute zero risk, radiological facilities are also required to maintain exposures as low as reasonably achievable (ALARA). Table 1 provides some of the more commonly encountered dose limits.

Table 1: Commonly Encountered Dose Limits for Exposures to Radiation

Dose Limit	Application
5,000 mrem/year	Maximum annual dose for radiation workers
100 mrem/year	Maximum dose to a member of the general public
25 mrem/year	Limit required by state regulations for free release of facilities that have been decommissioned
2 mrem in any one hour period	The state limit for the maximum dose in an unrestricted area in any one hour period

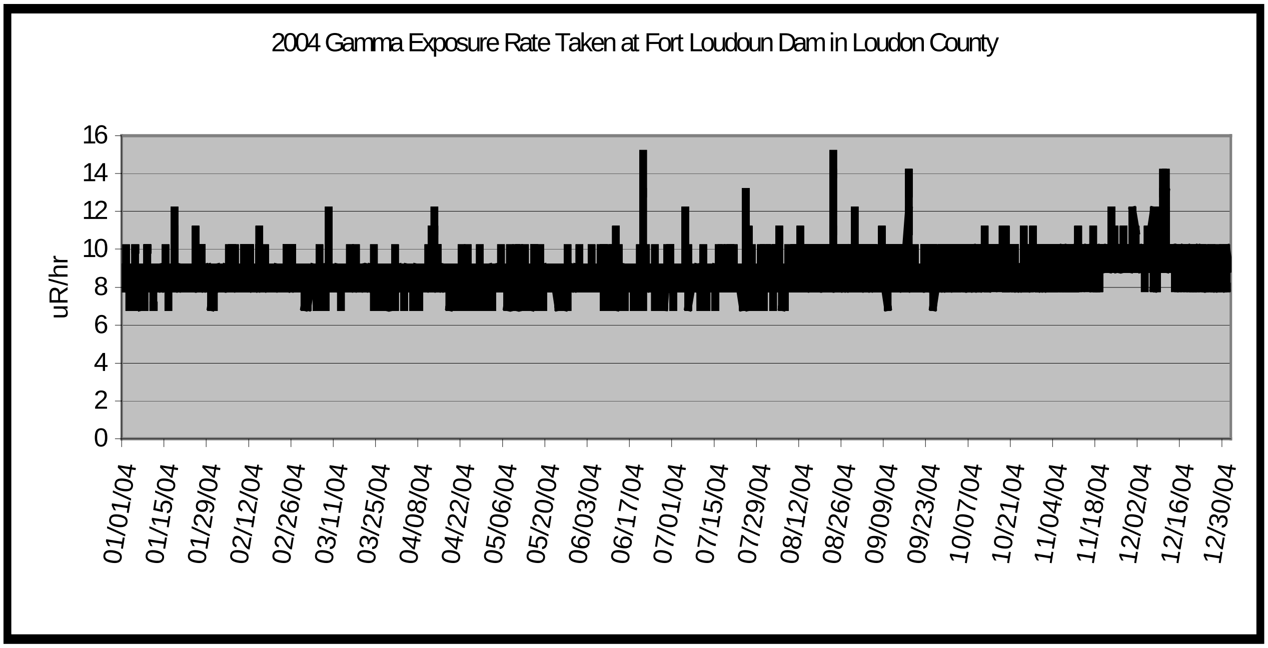
The unit used to express the limits (rem) refers to the dose of radiation an individual receives: that is, the radiation absorbed by the individual. For alpha and neutron radiation, the measured quantity of exposure, roentgen (R), is multiplied by a quality factor to derive the dose. For gamma radiation, the roentgen and the rem are generally considered equivalent. It should be understood, the monitors used in this program only account for the doses attributable to external exposures from gamma radiation. Any dose contribution from alpha, beta, or neutron radiation would be in addition to the measurements reported.

In 2004, gamma monitoring stations for the program included the background location at Fort Loudoun Dam in Loudon County, SWSA 5 North (Melton Valley Remedial Action), Y-12's Industrial Landfill, the 3513 Waste Holding Basin at ORNL, the Environmental Restoration Coal Yard Storage Area at ORNL, and the weigh-in station for the EMWMF in Bear Creek Valley near the Y-12 National Security Complex.

Fort Loudoun Dam Background Station: Background exposure rates fluctuate over time due to various phenomena that alter the quantity of radionuclides in the environment and / or the intensity of radiation being emitted by these radionuclides. For example, the gamma exposure rate above soils saturated with water after a rain can be expected to be lower than that over dry soils, because the moisture shields radiation released by terrestrial radionuclides. To better assess exposure rates

* Dose equivalent is the product of the absorbed dose in tissue and a quality factor. Total Effective Dose Equivalent means the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). The deep dose equivalent refers to the dose equivalent in tissue at 1 cm derived from external (penetrating) radiation. Dose contributions from background radiation and medical applications are not included in the dose calculation.

measured on the reservation and the influence that natural conditions have on these rates, division personnel maintain one of the division's gamma monitors at Fort Loudoun Dam in Loudon County to collect background information. Figure 1 depicts the exposure rates measured at the background station from 01/01/04 to 12/31/04. Over this period exposure rates averaged 9 µR/hr and ranged from 7 to 15 µR/hr.



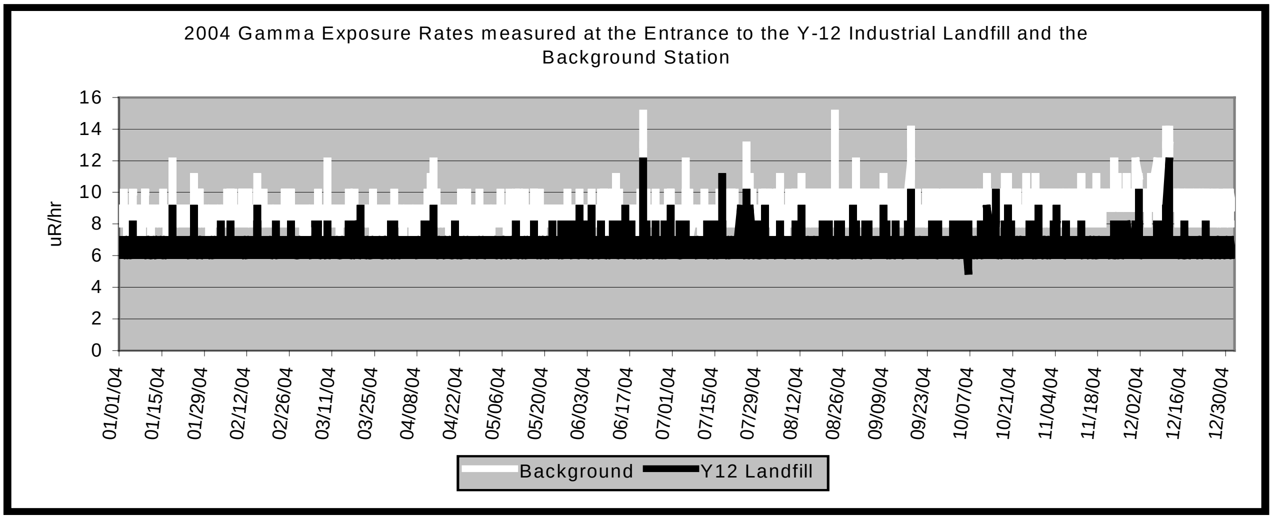
The state dose limit to an unrestricted area is 2 mrem (2,000 µR for gamma) in any one-hour period. The state dose limit for members of the public is 100 mrem in a year.

Figure 1: 2004 Results of Exposure Rate Monitoring at the Background Station located at Fort Loudoun Dam in Loudon County

On average, individuals in the United States receive a dose from natural sources of radiation of approximately 300 mrem per year. To put the dose limits in perspective, a person exposed solely to naturally occurring gamma radiation, at the average level recorded at Fort Loudoun Dam (9 µR/hr) would receive a dose equivalent to the primary dose limit (100 mrem/yr) in 496 days.

The Y-12 Industrial Landfill: The Y-12 Industrial Landfill is permitted by TDEC's Division of Solid Waste Management with the provision that the facility shall not dispose of radioactive Wastes. While wastes are screened prior to disposal at the facility, instances have occurred where radionuclides have been found at the landfill in violation of this agreement.

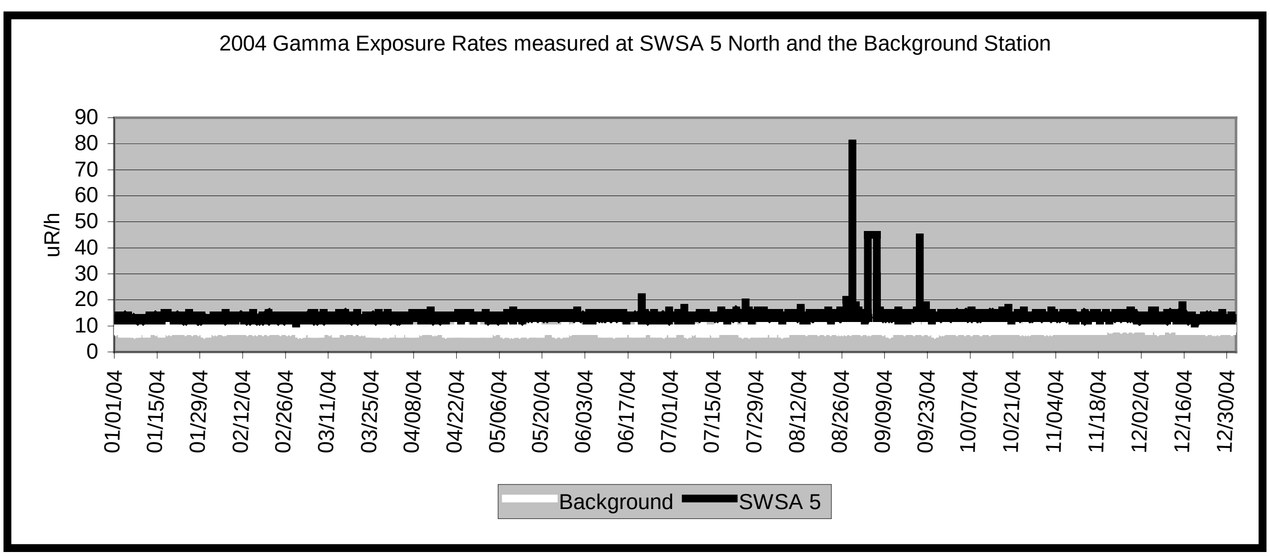
On 12/11/02, staff placed one of the gamma monitors at the entrance to the facility to measure gamma activity as wastes were transported through the gate for disposal. The monitor was programmed to increase the frequency of measurements recorded from one-hour to one-minute intervals, if exposure levels exceeded 20 µR/hr. To date, the results have all been similar to background measurements, except for one occasion when a calibration source being used at the site was detected by the monitor. For 2004, the measurements ranged from 5 to 12 µR/hr and averaged 7 µR/hr (Figure 2).



The state dose limit to an unrestricted area is 2 mrem (2,000 μR for gamma) in any one-hour period. The state dose limit for members of the public is 100 mrem in a year.

Figure 2: 2004 Gamma Exposure Rates measured at the Entrance to the Y-12 Industrial Landfill and Background Station (Fort Loudoun Dam)

<u>*Solid Waste Storage Area (SWSA) 5 North, Melton Valley Remedial Action*</u>*:* From 1970 to 1984, SWSA 5 North was used for the storage of high activity alpha emitting wastes, including remote handled transuranic waste and spent nuclear fuel (SNF). A gamma monitor was placed at the site in 2003 to monitor the transfer of SNF into shipping casks and onto trucks for transport to the Idaho National Engineering and Environmental Laboratory (INEEL). No releases were noted during the process, but it was decided to leave the unit in place to monitor remedial activities at the site. These activities include the retrieval of transuranic waste buried in 22 trenches, during the 1970s. The results for 2004 ranged from 11 to 80 μR/hr and averaged 14 μR/hr. Ambient levels recorded were consistently higher than the background data, which is believed to be due to historical release. Periods in August and September with considerably higher results (Figure 3) are believed to be associated with current remedial activities.



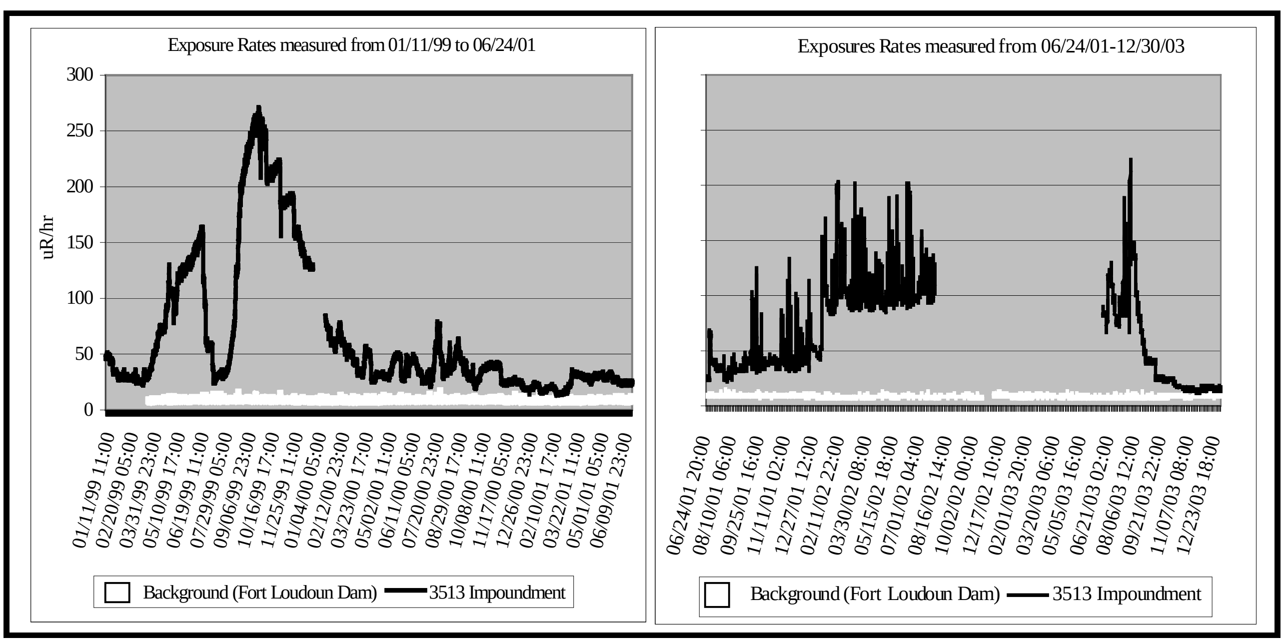
The state dose limit to an unrestricted area is 2 mrem (2,000 μR for gamma) in any one-hour period. The state dose limit for members of the public is 100 mrem in a year.

Figure 3: 2004 Gamma Exposure Rates measured at Solid Waste Storage Area 5 North and Background Measurements (Fort Loudoun Dam)

<u>*3513 Waste Holding Basin, Surface Impoundment Operable Unit (SIOU) Remedial Action:*</u> From 1944 to 1976, the 3513 Waste Holding Basin served as a settling pond for ORNL effluents prior to their release to White Oak Creek. Consequently, sediments at the bottom of the basin accumulated significant amounts of radioactive materials. Radioactive components included cesium-137, strontium-90, cobolt-60, europium-154, plutonium-238, plutonium-239, americium-241, and curium-244 (Bechtel, 1992): A Superfund Record of Decision issued September 24, 1997 provided for the removal and disposal of the contaminated sediments in the 3513 Impoundment and the adjacent 3524 Equalization Basin, which also received radioactive wastes, historically.

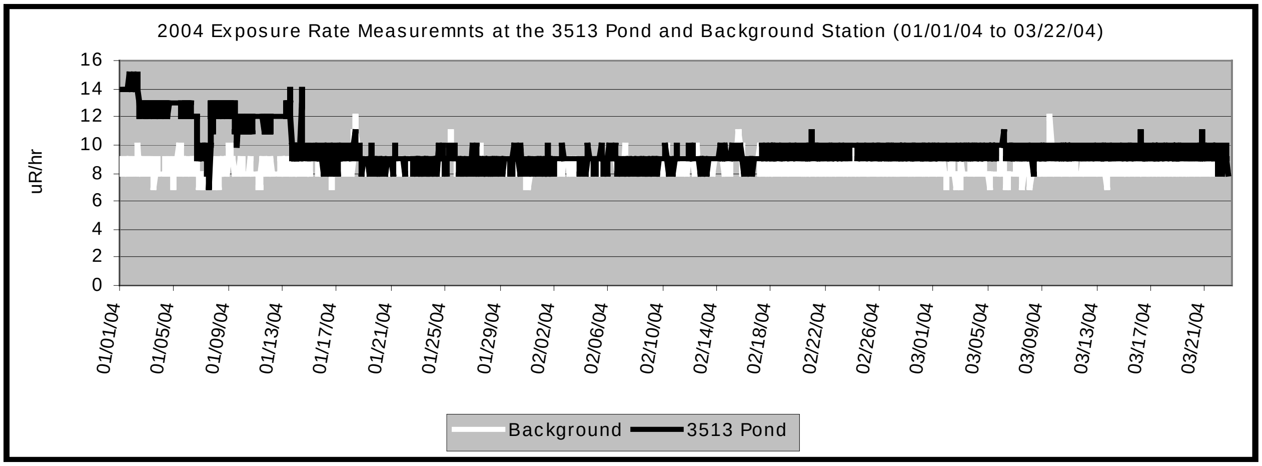
In order to measure the effectiveness of the action, division staff attached an exposure rate monitor to a tree located approximately 28 feet from the 3513 Impoundment in 1999 (prior to remedial activities). From 01/11/99 through 012/30/03 (after completion of the project) the exposure rates measured at the basin averaged 69 μR/hr and ranged from 11 to 271 μR/hr.

During the five years the 3513 Waste Holding Basin was monitored, the gamma exposure rates were highly variable (Figure 4). To a large degree, changes in the exposure levels could be correlated with fluctuations in the water levels in the basin. When the water level was low, contaminated sediments at the basin perimeter were exposed, resulting in higher exposure rates. As the water levels rose, shielding was provided from the radiation emitted by the previously exposed sediments and the exposure rates decreased. In 1999, prior to remedial activities, the exposure rates ranged from 13 to 271 μR/hr and averaged 116 μR/hr. After the sediments were removed and the impoundment filled, the exposure rates declined an order of magnitude and were consistently averaging approximately 16 μR/hr over the last quarter of 2003. As can be seen in Figure 5, measurements taken in 2004 were similar to the results recorded at the background station.



The state dose limit to an unrestricted area is 2 mrem (2,000 μR for gamma) in any one-hour period. The state dose limit for members of the public is 100 mrem in a year.

Figure 4: 1999-2003 Results for Gamma Exposure Rate Monitoring during the Remediation of the 3513 Waste Holding Basin

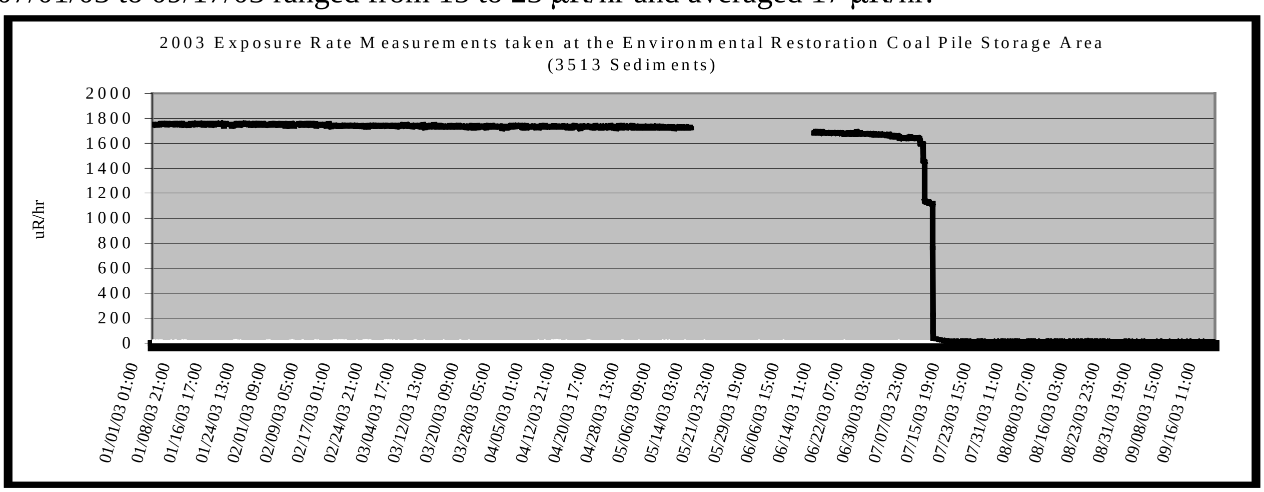


The state dose limit to an unrestricted area is 2 mrem (2,000 μR for gamma) in any one-hour period. The state dose limit for members of the public is 100 mrem in a year.

Figure 5: 2004 Results of Gamma Exposure Rate monitoring at the 3513 Waste Holding Basin and Background Measurements Taken at Fort Loudoun Dam (01/01/04 to 3/22/04)

Environmental Restoration Coal Yard Storage Area: As sediments were removed from the 3513 Basin, they were dewatered then mixed with cement to form large concrete monoliths. No longer shielded by the water in the pond, the monoliths were packaged in Department of Transportation liners and stored in radiation control areas at various locations across the ORNL campus. To assess the hazard the sediments might present, a gamma monitor was placed near the radiation area boundary at one of these sites, the Environmental Restoration Coal Yard Storage Area.

Results for January 1 through May 12, 2003, (when monitoring was interrupted) ranged from 1,712 to 1,764 μR/hr (Figure 6) and averaged 1,739 μR/hr. These are some of the highest levels that have been measured in the program. While not a DOE regulation, the highest result is approximately 88% of the State and Nuclear Regulatory Commission (NRC) dose limit for unrestricted areas, 2 mrem in any one-hour period. As the sediment monoliths were removed from the storage area for disposal, the exposure rates abruptly declined. Measurements taken from 07/01/03 to 09/17/03 ranged from 15 to 23 μR/hr and averaged 17 μR/hr.

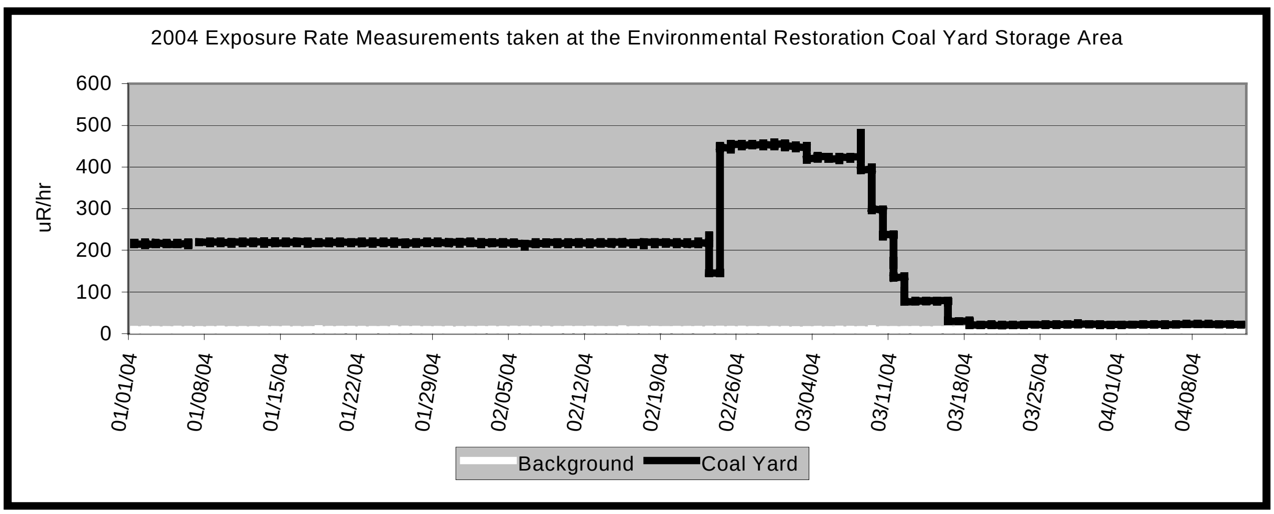


The state dose limit to an unrestricted area is 2 mrem (2,000 μR for gamma) in any one-hour period. The state dose limit for members of the public is 100 mrem in a year.

Figure 6: 2003 Results of Gamma Exposure Rate Monitoring at the Environmental Restoration Coal Yard Storage Area and Background Measurements

The radiation area boundary at the site was later reduced to the size necessary to surround soils excavated from the North Tank Farm in association with the Corehole 8 Remediation. The North Tank Farm is located near the center of ORNL's main campus. In the past, a number of underground storage tanks were emplaced at this location to store and/or treat radioactive and hazardous wastes. In the late 1990s, one of these tanks, W-1A, was discovered to be the source of the Corehole 8 groundwater plume, which covers a large area adjacent and to the west of the site. Contaminants associated with this plume include strontium-90, americium-241, plutonium-238, 239, 240, and curium-244 (Bechtel, 1992). The contaminants discharge to First Creek and are transported to White Oak Creek and the Clinch River. In 1998, DOE proposed to remove W-1A and the adjacent soils, which have developed into a secondary source of contamination feeding the plume. The removal action began in 2001, but was suspended after radiation levels were encountered much higher than the remedial contractor had anticipated. Soils that had been excavated from the site were moved to the storage area.

One of the division's environmental dosimeters was placed near the new boundary for the Coal Yard Storage Area storage area in October 2003. The dose reported for the quarter was 2,669 mrem; the second highest measurement reported for the period. Consequently, staff placed an exposure rate monitor at the new boundary in January of 2004. Data for 01/01/04 to 04/12/04 ranged from 8 to 483 μR/hr and averaged 188 μR/hr. As with the 3513 sediments, the results significantly declined after the Corehole 8 waste was removed for disposal (Figure 7).



The state dose limit to an unrestricted area is 2 mrem (2,000 μR for gamma) in any one-hour period. The state dose limit for members of the public is 100 mrem in a year.

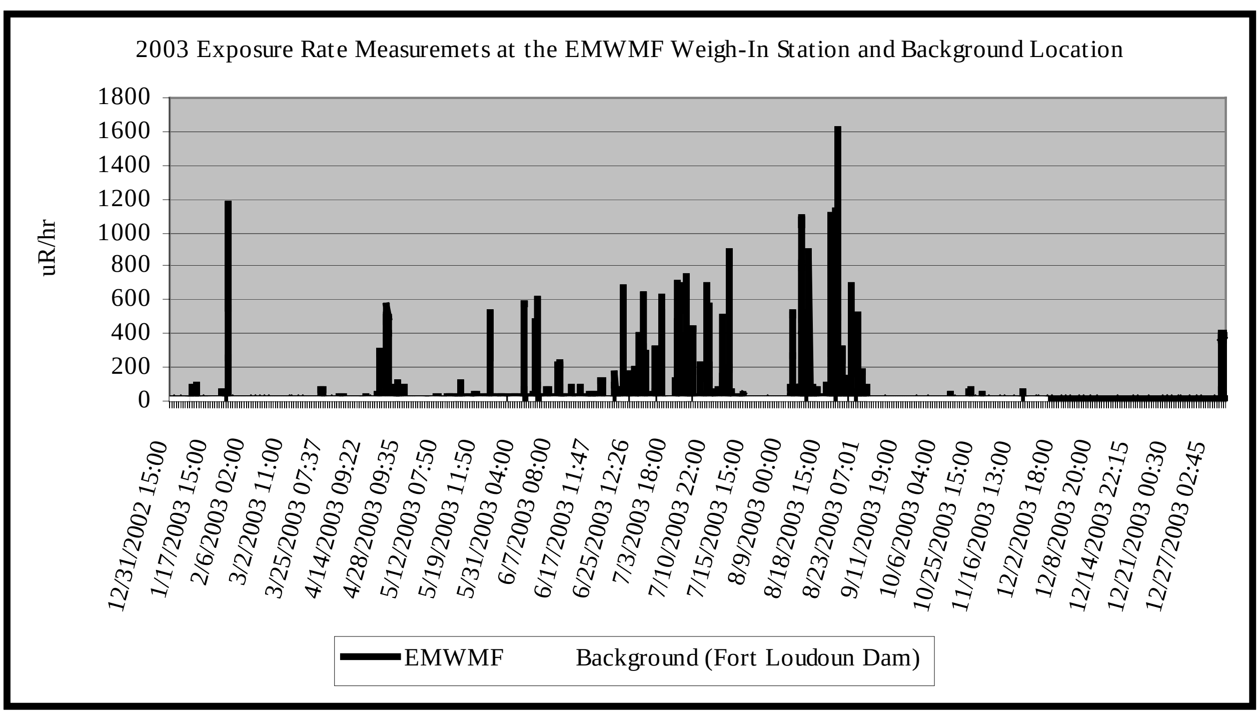
Figure 7: 2004 Results of Gamma Exposure Rate Monitoring at the Environmental Restoration Coal Yard Storage Area and Background Measurements

<u>The Environmental Management Waste Management Facility (EMWMF)</u>: The EMWMF was constructed in Bear Creek Valley (near the Y-12 Plant) to dispose of wastes generated by CERCLA activities on the ORR. The EMWMF relies on a waste profile provided by the generator to characterize waste disposed in the facility. This profile is based on an average of contaminants in a waste lot. Since the size of waste lots can vary from a single package to many truckloads of waste, the averages reported are not necessarily representative of each load of waste transported to the facility. That is, some loads may have highly contaminated wastes, while other loads may contain very little contamination.

To get an idea of the variability in radioactive waste disposed at the EMWMF, one of the gamma monitors was secured at the facility's check-in station on 08/27/02. Each truck transporting waste for disposal is required to stop at this location while the vehicle/waste is weighed and the driver processes the associated manifest. In 2004, the monitor was programmed to record measurements at fifteen-minute intervals at exposure rates below 40 μR/hr and at one-minute intervals at exposure levels above 40 μR/hr.

When waste containing gamma emitters are not near the weigh station, the data reflects exposure levels similar to background measurements. As the trucks carrying gamma emitters pull into the weigh station, the exposure levels go up, peak as the waste moves past the monitor, then abruptly decline as the trucks pull away. While relatively high measurements can be observed in the data, the durations of the elevated readings are only a few minutes. This, coupled with the monitor's inability to read alpha and beta emissions, results in relatively low average values when compared to the maximum exposures measured.

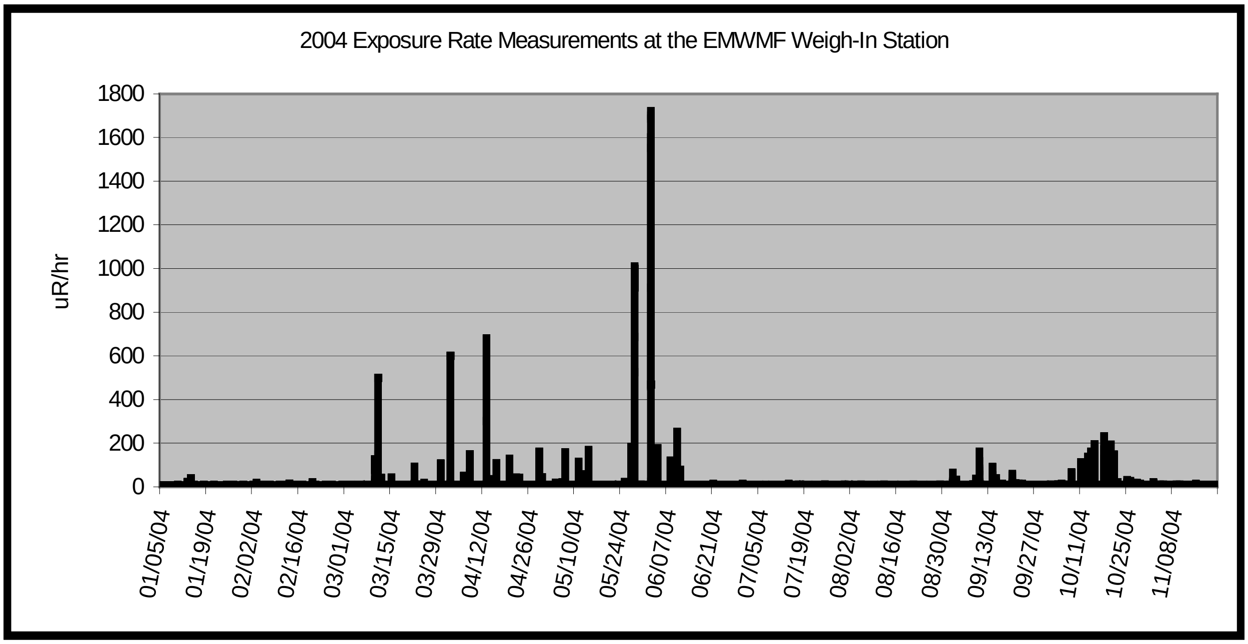
In 2003, the highest measurements at the EMWMF were during the delivery of the sediments dredged from the 3513 Waste Holding Basin (Figure 8). The highest of these measurements, 1,612 μR/hr, represents 81% of the state's maximum dose to an unrestricted area in any one-hour period. Because of the radiological characteristics of the waste, it had initially been dispositioned for disposal at the Nevada Test Site (NTS). However, a rule change at NTS resulted in the wastes being rejected because of the presences of PCBs. The sediments were subsequently accepted by the EMWMF.



The state dose limit to an unrestricted area is 2 mrem (2,000 μR for gamma) in any one-hour period. The state dose limit for members of the public is 100 mrem in a year.

Figure 8: 2003 Results of Gamma Exposure Rate Monitoring at the Weigh-In Station for the Environmental Management Waste Management Facility (EMWMF)

For 2004, the measurements taken at the EMWMF ranged from 1 to 1720 μR/hr (Figure 9) and averaged 9.25 μR/hr. The highest exposure rates recorded in 2004 were taken at the EMWMF during the delivery of wastes associated with the Corehole 8 Remediation at ORNL. These measurements included the five highest peaks that can be observed in Figure 9: 500 μR/hr on 03/11/04, 600 μR/hr on 04/02/04, 680 μR/hr on 04/13/04, 1010 μR/hr on 05/28/04, and 1720 μR/hr on 06/02/04. The highest value, 1,720 μR/hr, represents approximately 86% of the state maximum dose to an unrestricted area in any one-hour period.



The state dose limit to an unrestricted area is 2 mrem (2,000 μR for gamma) in any one-hour period. The state dose limit for members of the public is 100 mrem in a year.

Figure 9: 2004 Results of Gamma Exposure Rate Monitoring at the Weigh-In Station for the Environmental Management Waste Management Facility (EMWMF)

Conclusion

The use of continuously recording gamma exposure monitors has proven to be a flexible and reliable method for monitoring gamma radiation on the reservation. Based on the data collected with the instruments in 2003 and 2004:

- Gamma levels at the Y-12 Industrial Landfill in 2003 and 2004 were not indicative of the presence of radioactive waste.
- Historic releases at SWSA 5 North appear to have resulted in ambient radiation levels above background measurements. Considerably higher results recorded at the site in August and September of 2004 are believed to be due to remedial activities.
- After removal of contaminated sediments and capping of the 3513 Waste Holding Basin, exposure rates at the location fell from an average of 116 μR/hr in 1999 to background levels in 2004.
- The highest exposure rate measured in the program (1,764 μR/hr) was recorded in 2003 at the Environmental Restoration Coal Yard Storage Area. The measurement was taken near the boundary of a radiation area surrounding the sediments from 3513 Waste Holding Basin. The value represents approximately 88% of the state's limit for the dose to an unrestricted area in any one-hour period.

- The highest exposure rate recorded at the EMWMF in 2003 was, also, from the sediments taken from the 3513 Waste Holding Basin. This measurement, 1,612 μR/hr, represents approximately 81% of the state's limit for the dose to a nonrestricted area in any one-hour period.
- The highest measurements taken in 2004 were at the EMWMF during the delivery of contaminated soils from Corehole 8 remedial activities. The highest measurement, 1,720 μR/hr, represents approximately 86% of the state's dose limit for unrestricted areas.

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CHAPTER 5 RADIOLOGICAL MONITORING

Biological Sampling and Radiochemical Analysis of Aquatic Plants (Macrophytes) at Spring Habitats on the Oak Ridge Reservation

Principal Author: Gerry Middleton/Robert Storms

Abstract
This project is an expansion of a pilot vegetation (watercress) sampling and radiochemical analysis effort begun by division staff in 1995 as part of environmental surveillance per the Tennessee Oversight Agreement. The project had been idle since that time due to inconclusive results and laboratory budget constraints. The project was revitalized in 2002. Metals were added in 2004 as potential contaminants of interest. The current study was designed to correlate previous TDEC and DOE groundwater radiochemistry data with watercress/vegetation radiochemistry data sampled from the same ORR springs as an aid in determining if aquatic vegetation is bio-accumulating radiological contaminants. Division staff gathered collateral vegetation monitoring data in support of the groundwater monitoring and sampling of springs and surface water impacted by hazardous substances. Sometimes, spring-fed creeks and ponds were sampled, if adequate amounts of aquatic vegetation were present. "Vegetation" sampled included watercress (*Rorippa nasturtium-aquaticum*), other aquatic macrophytes (i.e., *Salvinia sp*., *Sagittaria latifolia,Typha latifolia,* etc), and green algae. Twenty-two vegetation samples from reference springs/creeks/ponds (offsite) and onsite springs/creeks/ponds were sampled during 2004. Collection times of samples was random as there was no need in this case to organize a schedule into wet and dry season sampling events.

Introduction
Aquatic macrophytes (i.e., watercress, water spangles, arrowhead, and cattails), lichens, mosses and green algae are environmental bioindicators and important pathways by which contaminants infiltrate the ORR ecosystem and food chain creating ecological and human health risks. Watercress, a floating, rooted, aquatic plant (macrophyte or angiosperm) was selected for its affinity to thrive around its natural habitat, in clear, lotic water near the mouth of springs and spring-fed creeks. Emerging spring water, if impacted by hazardous substances, will deposit these substances in sediments. In turn, plants will uptake the contaminants both from the water and the sediments. Watercress is naturally high in calcium, alkaline salts, sulfur, and potassium, so it is likely that strontium (a beta emitter) would be uptaken as well, since calcium and strontium belong to the same group (Group IIA) of the periodic chart of the elements. Also, potassium and cesium belong to Group IA creating a similar scenario. Watercress sample analytical results collected during Phase 1 sampling (2002) support this theory as two samples exhibited low Cesium-137 concentrations. During the first year of this project, watercress was the main bioindicator sampled supplemented with a few green algae, periphyton and macrophyte samples. Sampling of algae or other aquatic macrophytes was initiated and substituted when watercress was absent or too sparse for sampling at spring sampling habitats.

Green algae and periphyton (benthic algae – diatoms) occur in most all the aqueous and many terrestrial habitats on the ORR (algae is ubiquitous). Algae forms colonies or filamentous mats ("blooms" or slick gelatinous mucilage) often covering a large area of a pond, waterfall ledges, lentic (still) or lotic (moving) water, or lake. Often they are attached to various substrates such as submerged logs and snags, aquatic plants, sand, gravel, rocks, etc. Periphyton biomass is a primary producer generating much of the low-end of the food chain for many aquatic macroinvertebrates, fish and herbivores. Periphyton are sensitive indicators of environmental physiochemical change in lotic waters. Since they are benthic, the assemblage or population serves as a good bioindicator due to their tolerance or sensitivity to specific changes in environmental condition known for many algal species including diatoms (modified from U.S. DOE, April 2001).

Prospective habitats both offsite and onsite the ORR such as springs, seeps, wetlands, ponds, spring-fed creeks, etc., received priority for sampling. Onsite ORR locations were selected based on their potential for being impacted by hazardous substances. Table I provides radiochemical field and sample data for each sampling station. Table 2 provides metal analysis for each sampling point. Existing historical spring (groundwater) analytical data collected by both the division and DOE subcontractors were used to target sampling sites as well. Maps 1, 2, and 3 depict the locations of the sampling sites.

Methods and Materials

Procedures employed during the project are consistent with those contained in the TDEC DOE-O Work Plan for the Walkover Survey Program for field radiological surveys and aquatic sampling. Radiological instruments were used to scan bagged samples for beta and gamma radiation prior to delivery to the state Environmental Laboratory in Knoxville. Subsequently, the Knoxville laboratory forwards all radiological samples to Nashville (state of Tennessee Environmental Laboratories) for radiochemical analysis.

Arrangements were made with the appropriate TOA coordinators to expedite sampling in radiological control areas by having radcon technicians available for sample and equipment screening. All samples collected in the field were double bagged in plastic zip-lock baggies, marked and tagged, and packed in coolers with ice for transport to the lab. Field notes and chain-of-custody forms were recorded and documented at each field sampling station. Field samples were assigned consecutive identification numbers (i.e., “Cress-01”, “Cress-02”). QA/QC measures and field sampling equipment decontamination procedures were practiced to prevent cross-contamination and mix-up of field samples. Field coordinates (latitude/longitude) were recorded at each sampling station using a Garmin GPS II Plus field unit. Field sampling protocols and methods followed currently accepted and suggested guidelines of the Federal Radiological Monitoring and Assessment Center (FRMAC, 1998), the USGS (Porter, et al., 1993), the ASTM (Patrick, 1973), the TDEC *“Health, Safety, and Security Plan,”* and the EPA (Barbour, et al., 1999).

Target radionuclides being mobile and occurring in the ORR environment as contamination include but are not limited to:

(1) Cesium-137
(2) Strontium-90
(3) Cobalt-60
(4) Technetium-90
(5) Uranium Isotopes and Daughter Products

Samples were analyzed for metals, gross alpha, gross beta, and gross gamma parameters. Samples are ashed in a muffle furnace and analyses are performed on the ashed sample material. The gamma analysis follows the standard EPA (gamma) 901.1 method. The gross alpha and gross beta analysis is determined by counting 2 grams of ashed sample for two separate counts of 100 minutes.

Results and Discussion

The objectives of this oversight activity and study are the detection and characterization of radionuclides and metals which are being bioaccumulated by both aquatic macrophytes and algal species in ORR spring habitats and aquatic ecosystems affecting the low-end food chain. The division gathered twenty-two (22) vegetation samples during 2004. A purpose of the study was to show that contaminated groundwater emerging from springs was also impacting aquatic plant species in the same sampling reach of the spring-fed creeks and streams. Historical spring groundwater sampling data from 2000 and 2001 was assimilated from both division and DOE monitoring data. Twelve (12) of twenty-two (22) division vegetation samples were compared to this historical spring groundwater analytical data. No groundwater data was available for the other locations.

In a few cases, the data shows a clear correlation of gross beta contamination between groundwater and aquatic vegetation, in samples collected from corresponding sites. However, at this time the correlation is too early to substantiate without further sampling. Future endeavors will focus on those areas with the highest radionuclide hits for both groundwater and aquatic vegetation with care taken to filter out high levels caused by radionuclides in fertilizers.

Conclusions

Adequate evidence of vegetation bioaccumulation of radionuclides has been determined to warrant further investigations. The analytical concentrations (especially gross beta) per the Table II radiological data suggests a correlation or "mimicry" between groundwater (pCi/L) and aquatic vegetation (pCi/g) samples collected from the same spring monitoring location(s). The division will continue to sample and monitor aquatic vegetation both offsite and on the ORR to monitor aquatic ecosystem health and stream recovery.

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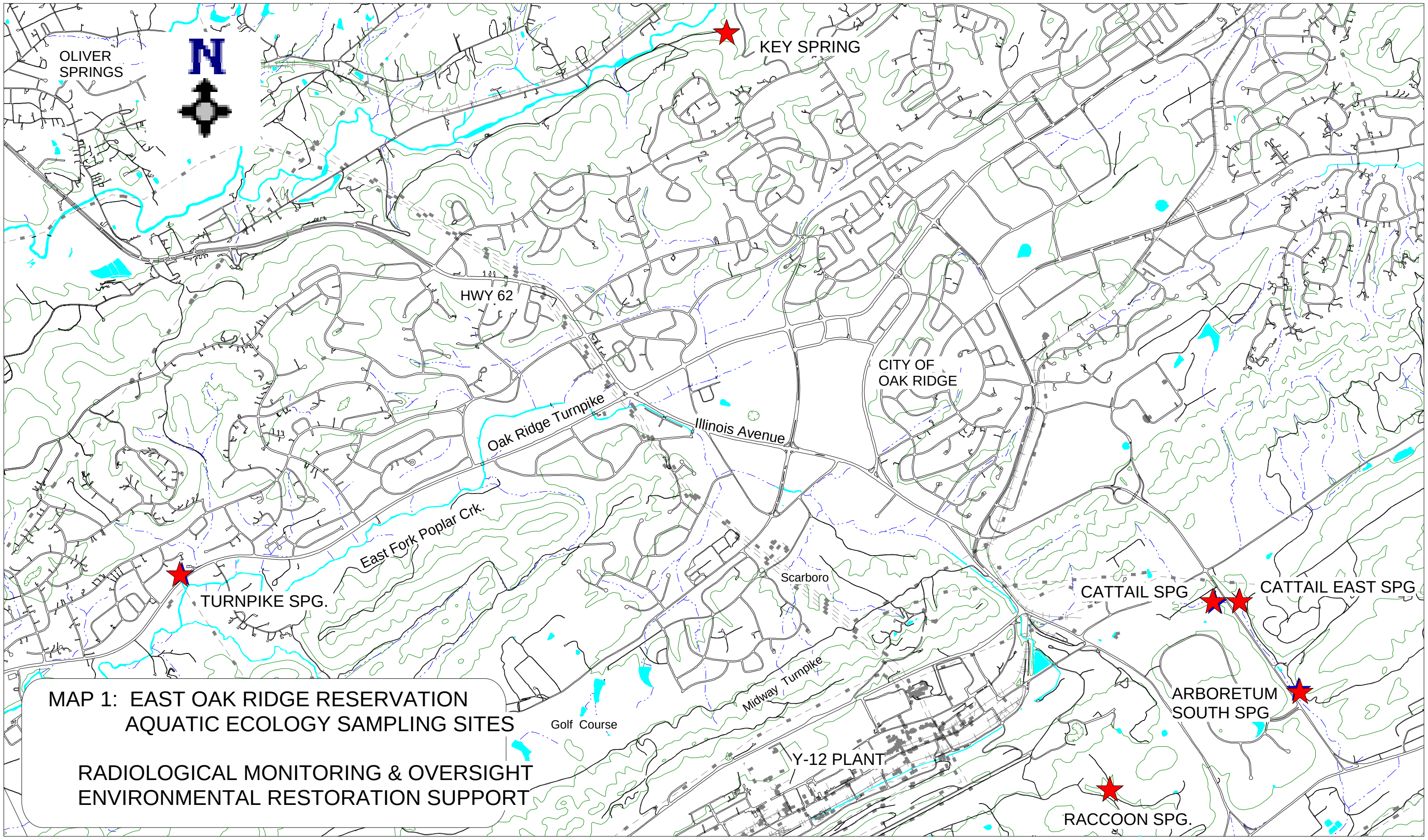
Table 1	**2004 Radiochemical Data**			
SAMPLE I.D.	**LOCATION / SAMPLE MATERIAL**	**GROSS ALPHA**	**GROSS BETA**	**GAMMA RADIONUCLIDES**
		(**pCi/g** / Error)	(**pCi/g** / Error)	**Nuclide**(s) / (**pCi/g** / Error)
BIOIND-39	Spring SS-2/Watercress	**0.066** /0.018	**3.50**/0.14	**K-40 =2.23**/0.21
BIOIND-40	Spring SS-5/Watercress	**0.099**/0.017	**4.369**/0.064	**K-40 =1.82**/0.14
BIOIND-41	Spring SS-6 East/Watercress	**0.075**/0.020	**3.206**/0.073	**K-40 = 1.65**/0.12
BIOIND-42	Key Spring/Watercress	**1.50**/0.042	**3.47** /0.13	**K-40 = 1.67**/0.12
BIOIND-43	Cattail Spring/Watercress	**0.121**/0.042	**4.53**/0.17	**K-40 =2.19**/0.11 **Be-7 = 0.305**/0.047
BIOIND-44	Guardshack Spring/Watercress	**0.0188**/0.0073	**2.599**/0.061	**K-40 = 1.46**/0.12
BIOIND-45	Beaver Dam Spring/Moss & Algae	**0.316**/0.070	**3.77**/0.17	**K-40 = 1.32**/0.13
BIOIND-46	Turnpike Spring/Watercress	**0.111**/0.040	**3.02**/0.15	**Bi-214 = 0.0506**/0.0064 **Tl-208 = 0.0167/**0.0031
BIOIND-47	Roger's Spring/Watercress	**0.217**/0.062	**2.72**/0.14	**Pb-212 = 0.082**/0.013
BIOIND-48	Cattail East Spring/Scouring Rush	**0.006**/0.057	**9.46**/0.35	**K-40 = 3.61**/0.22 **Be-7 = 1.41**/0.12
BIOIND-49	UT Arboretum South Spring/W-cress	**0.317**/0.086	**4.20**/0.23	**K-40 = 1.93**/0.14
BIOIND-50	Mt. Vernon Spring/W-cress + Algae	**0.542**/0.081	**4.23**/0.17	**K-40 = 1.18**/0.15
BIOIND-51	Mt. Vernon Spring/Watercress	**0.355**/0.059	**3.77**/0.14	**K-40 = 1.45**/0.17
BIOIND-52	Mt. Vernon Spring/Green Algae	**0.85**/0.13	**4.87**/0.24	**K-40 = 1.17**/0.22 **Be-7 = 0.63**/0.16
BIOIND-53	Raccoon Spring/Watercress	**0.121**/0.028	**2.569**/0.089	**K-40** = **1.06**/0.13
BIOIND-54	ETTP K1007-Pond 1(East)/Algae	**0.077**/0.079	**3.73**/0.24	**Be-7** =**2.69**/0.15 **K-40** = **1.49**/0.15
BIOIND-55	ETTP K1007-Pond 1 (West)/Algae	**0.194**/0.081	**5.93**/0.081	**Be-7** = **1.22**/0.18
BIOIND-56	Lambert Quarry (East)/Green Algae	**0.044**/0.094	**1.48**/0.20	**Be-7** = **1.579**/0.076
BIOIND-57	SNS Wetland/Watercress	**0.061**/0.018	**2.744**/0.064	**K-40 = 1.37**/0.17
BIOIND-58	Sadachbia Spring/*Najas* (Waterweed)	**0.092**/0.040	**2.54**/0.12	**K-40 = 1.09**/0.12
BIOIND-59	Upper McCoy Branch/Watercress	**0.041**/0.015	**3.387**/0.076	**K-40 = 1.86**/0.11
BIOIND-60	SNS Spring/Mixed Wetland Vegetation	**0.101**/0.034	**4.54**/0.15	**K-40 = 2.31**/0.15
				NOTE: Shaded box (es) represents the highest pCi/g reported value.

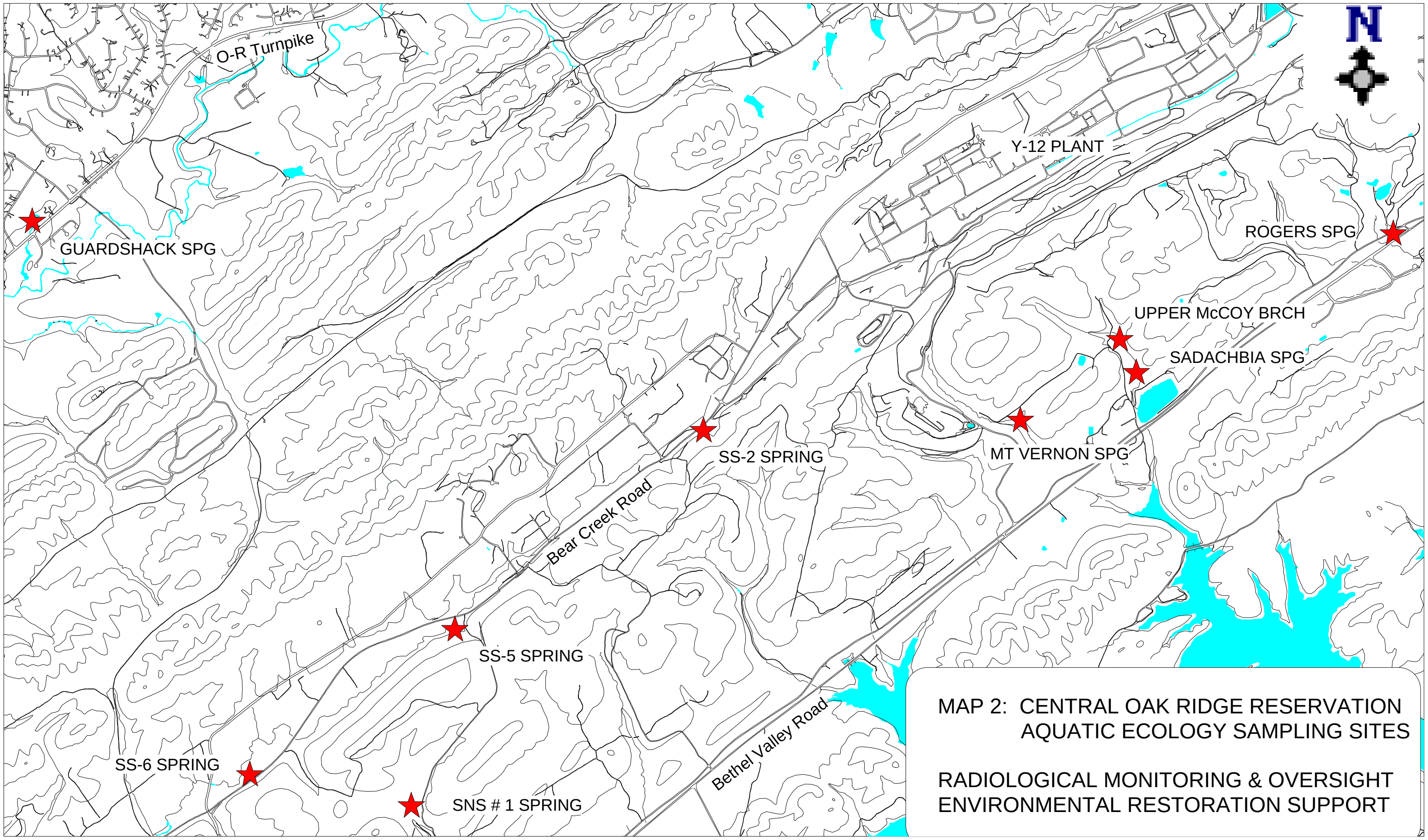
TABLE 2: 2004 AQUATIC VEGETATION ANALYTICAL RESULTS - METALS

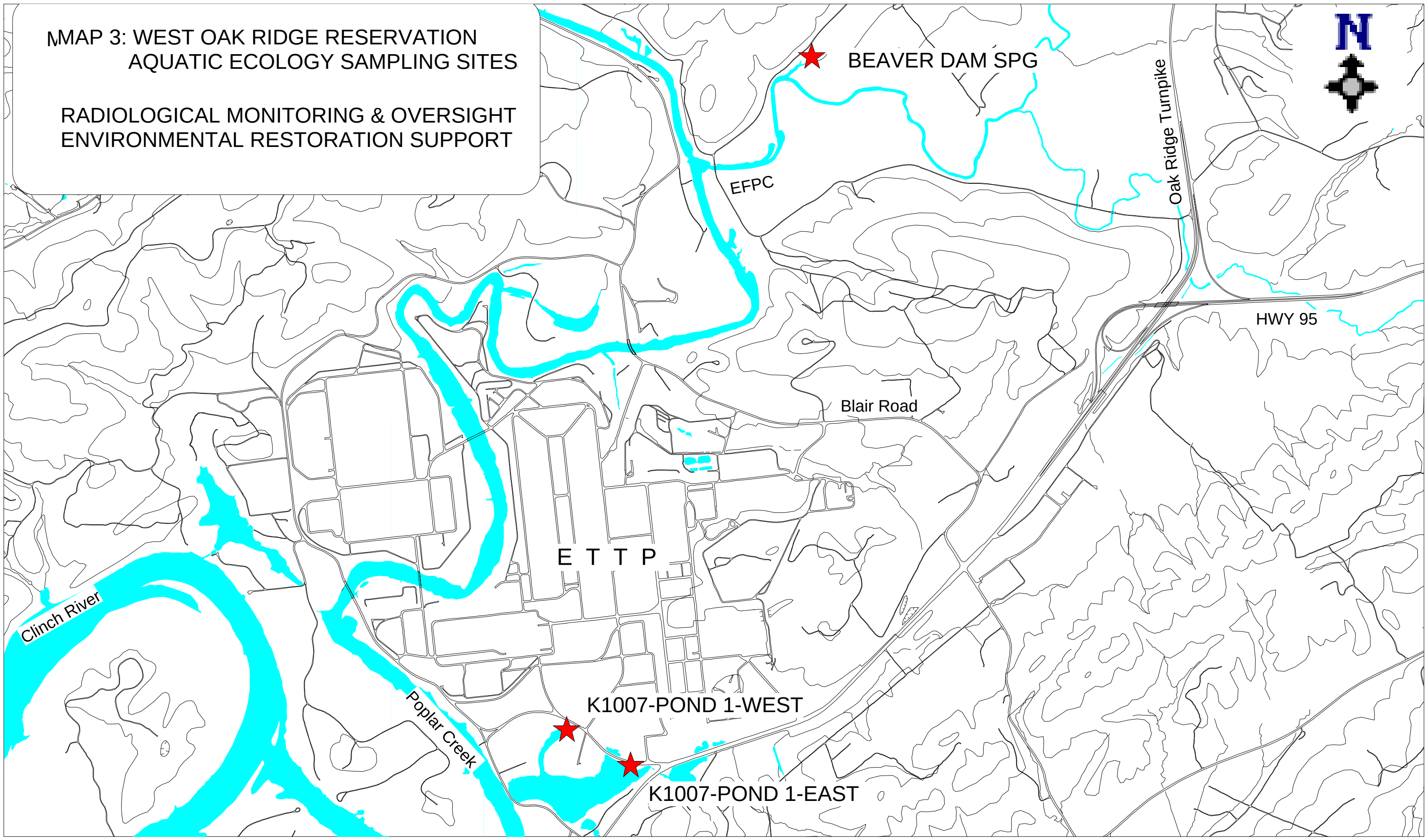
SAMPLE I.D.	LOCATION / SAMPLE MATERIAL	Al	Sb	As	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Hg	Ni		Zn	% Solids
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)		(mg/kg)	(percent)
BIOIND-39	Spring SS-2/ Watercress	23000	U	25	4.2	5.7	67300	28.8	32.6	52.9	16500	63.1	17700	U	80		643	1.65%
BIOIND-40	Spring SS-5/ Watercress	23000	U	15	1.4	8.1	71600	17	17.9	46.5	13900	23.5	19000	U	34		527	1.01%
BIOIND-41	Spring SS-6 East /Watercress	24700	U	21	0.9	1.3	33700	25.4	23.1	29.6	24100	58.5	10800	U	22		246	1.69%
BIOIND-42	Key Spring/ Watercress	27200	U	26	3.3	3.2	41300	24.2	45.8	45.6	26000	345	15900	U	59		521	3.30%
BIOIND-43	Cattail Spring/ Watercress	27000	U	2	0.8	1.2	28300	42.6	27.1	20.4	31900	19.8	6670	U	27		498	4.10%
BIOIND-44	Guardshack Spring/ Watercress	9620	U	3	1.3	2.5	62300	18	15	15.6	14900	3.1	21500	U	18		633	0.80%
BIOIND-45	Beaver Dam Spring/Moss & Algae	24100	U	U	7.6	2.6	30800	24.4	14.6	28.6	15400	19.1	9660	U	42		415	4.80%
BIOIND-46	Turnpike Spring/ Watercress	21500	U	6	0.9	1.1	25900	22	21.4	28	24000	41.8	4620	U	21		145	4.20%
BIOIND-47	Roger's Spring/ Watercress	14700	U	U	0.6	1.6	42500	26.1	33.6	51.6	23300	22.8	7100	U	20.2		276	9.56%
BIOIND-48	Cattail East Spring/ Scouring Rush	5220	U	2.5	U	U	107000	3.6	3.9	19.2	2920	U	24400	U	4		130	8.59%
BIOIND-49	UT Arboretum South Spring/ Watercress	14700	U	4.5	4.4	4.1	22800	43.7	20.3	16.5	25400	31.6	7080	U	26.7		663	17.10%
BIOIND-50	Mt. Vernon Spring/ Watercress + Algae	24200	U	5.1	0.8	0.7	43000	22.3	18.8	18.4	34600	25.3	10400	U	20.4		253	5.97%
BIOIND-51	Mt. Vernon Spring/ Watercress	20600	U	14.7	0.7	0.4	40200	18.8	21.3	13.6	41800	23	13200	U	19.1		181	4.65%

TABLE 2 cont'd: 2004 AQUATIC VEGETATION ANALYTICAL RESULTS - METALS

SAMPLE I.D.	LOCATION / SAMPLE MATERIAL	Al	Sb	As	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Hg	Ni		Zn	% Solids
	Mt. Vernon Spring/ ALGAE	26900	U	8.2	1	1.1	41100	25.2	15.8	16.1	27600	29.5	8590	U	22.6		316	9.49%
BIOIND-53	Raccoon Spring/ Watercress	23600	U	15	4.5	3.9	41400	24.6	48.8	32.1	14900	23.1	9570	U	52		351	2.54%
BIOIND-54	ETTP K1007-Pond 1 (East) /Algae	16600	U	U	U	0.8	158000	41.1	6.8	40.7	15200	22.6	8100	U	29		374	11.90%
BIOIND-55	ETTP K1007-Pond 1 (West)/ Algae	NO SAMP																
BIOIND-56	Lambert Quarry (East)/ Green Algae	4720	U	U	U	U	223000	3.7	3.9	1.5	3000	U	8600	U	6		17.1	12.40%
BIOIND-57	Sadachbia Spring/ Watercress	29600	U	11	0.7	3	83700	43.6	56.7	40.5	44100	16.9	16800	U	23.3		512	3.97%
BIOIND-58	Sadachbia Spring/ *Najas sp.* (waterweed)	22400	U	60	0.6	1.1	101000	21.9	13.8	27.2	41700	10.1	9190	U	26		211	3.65%
BIOIND-59	Upper McCoy Branch/ Watercress	16700	U	128	0.1	5.8	69400	17.8	27.7	43.3	36100	5.5	13200	U	26		1420	1.21%
BIOIND-60	SNS Spring/ Mixed Wetland Vegetation	6450	U	5	1.1	2.2	31800	14	20	10.5	6830	7.7	12300	U	10		330	3.19%


OLIVER SPRINGS
N
KEY SPRING
HWY 62
CITY OF OAK RIDGE
Oak Ridge Turnpike
Illinois Avenue
East Fork Poplar Crk.
TURNPIKE SPG.
Scarboro
CATTAIL SPG
CATTAIL EAST SPG
ARBORETUM SOUTH SPG
Midway Turnpike
Golf Course
Y-12 PLANT
RACCOON SPG.
MAP 1: EAST OAK RIDGE RESERVATION
AQUATIC ECOLOGY SAMPLING SITES
RADIOLOGICAL MONITORING & OVERSIGHT
ENVIRONMENTAL RESTORATION SUPPORT


O-R Turnpike
Y-12 PLANT
GUARDSHACK SPG
ROGERS SPG
UPPER McCOY BRCH
SADACHBIA SPG
MT VERNON SPG
SS-2 SPRING
Bear Creek Road
SS-5 SPRING
SS-6 SPRING
SNS # 1 SPRING
Bethel Valley Road
N
MAP 2: CENTRAL OAK RIDGE RESERVATION
AQUATIC ECOLOGY SAMPLING SITES
RADIOLOGICAL MONITORING & OVERSIGHT
ENVIRONMENTAL RESTORATION SUPPORT



MMAP 3: WEST OAK RIDGE RESERVATION
AQUATIC ECOLOGY SAMPLING SITES
RADIOLOGICAL MONITORING & OVERSIGHT
ENVIRONMENTAL RESTORATION SUPPORT
N
BEAVER DAM SPG
EFPC
Oak Ridge Turnpike
HWY 95
Blair Road
E T T P
Clinch River
Poplar Creek
K1007-POND 1-WEST
K1007-POND 1-EAST

CHAPTER 5 RADIOLOGICAL MONITORING

2004 Field Botany: Mapping Native and Invasive Plant Species on the 3000 Acre Black Oak Ridge Conservation Easement (BORCE)

Abstract

The project was conceptualized during the summer of 2003 following developments relevant to the DOE transfer of the Black Oak Ridge Conservation Easement ("BORCE") tract of land to the State of Tennessee. The BORCE consists of approximately 3,000 acres on Blackoak and McKinney Ridges and has been proposed for inclusion in a conservation easement between the State of Tennessee and the Department of Energy (per a December 20, 2002 "Letter of Intent") pursuant to the Natural Resources Damages Assessment (NRDA) as partial repayment for natural resource damages to the Clinch River and Watts Bar Reservoir resulting from federal activities on the ORR. The agreement was nearing the finalization stages for approval and acceptance by both parties (including public comment) during late 2004. The Tennessee Wildlife Resources Agency (TWRA), in consultation with TDEC, will have the state lead for management of the BORCE. The site management plan is available for reading online at the following web address: http://www.state.tn.us/environment/doeo/doeoppo/BORdraftmgtplan.pdf. As a result of this proposal, the division determined to take a proactive role in establishing plant biodiversity as natural resources on this parcel (including the exotic species). Accordingly, during 2003, fieldwork was completed on approximately half of the BORCE (mainly East Blackoak & McKinney Ridge areas), as about 250 field stations (mini-plots) were logged, and during 2004, an additional 100 field stations were recorded on the West Blackoak Ridge portion (see Figure 2). The project incorporates the division's role of environmental surveillance, and the field survey of plant species will more thoroughly document the resource management needs of this easement parcel.

Introduction

The BORCE is nestled in the rugged Blackoak Ridge terrain of the northwest section of the Oak Ridge Reservation and is located in Roane County, Tennessee. The 3,000 acre site is subdivided into two main management units: (1) the natural area section situated north of the ED-1 industrial park site will be known as the East Blackoak Ridge area (EBOR) which includes McKinney Ridge with a combined ~1400 acres, and is part of the NERP (National Environmental Research Park), and (2) the wildlife management section situated north of the ETTP will be known as the West Blackoak Ridge (WBOR) area with ~1600 acres. The north, east and west perimeter of the EBOR is a gravel road also being the North Boundary Greenway trail. Figure 1 shows the general location and tentative boundary of the BORCE.

Prominent natural and ecological features of the BORCE include:

- Black Oak Ridge / McKinney Ridge
- Limestone outcrops / karst features
- Mixed hardwood-native pine forest
- Large forested wetland
- East Fork Poplar Creek / Poplar Creek / Clinch River
- River bluffs
- Boreal forest (rhododendron/hemlock/mountain laurel)
- Southern red oak-tulip tree-white oak-pine-hickory forests

- Tulip tree-southern red oak-white oak forests
- Northern red oak-tulip tree-white oak forests
- Threatened & Endangered plant species (Ginseng/Goldenseal/Appalachian Bugbane/Pink lady Slipper/White-topped sedge)

Cultural resources include:
- Pre-Manhattan homesteads / associated structures
- Native American cultural sites
- 5 historic cemeteries

Threats to the BORCE Natural Resources:
- Illegal digging of rare and protected plants
- Exotic invasive plant species colonizing the diseased and now mostly dead and fallen pine plantations
- Introduction of non-native plant species due to horse-riding (prohibited)
- Illegal use of motorized vehicles within the BORCE
- Fragmentation of or encroachment upon the BORCE (sale of small parcels to local governments & developers, building interior roads, etc.)

Goals of the Project
- During 2005/2006, complete the BORCE plant mapping project.
- Provide field and logistical support to the TDEC Division of Natural Heritage relating to botanical issues on the Oak Ridge Reservation.
- Define, identify, locate and assess the natural resources of the BORCE, even those that may be detrimental (i.e., especially exotic invasive plant species).
- Share project information with the public and sister state agencies (TWRA, TDEC Division of Natural Heritage, etc.) to develop corrective actions for the removal or eradication of the exotic plants from the most infested areas. Develop a long-term invasive plant management plan with the assistance of the Southeast Exotic Pest Plant Council.
- Monitor populations of threatened and endangered species within the entire 3,000 acres of the BORCE and report (and document) new finds to the TDEC Division of Natural Heritage.
- Monitor the extensive pine deadfall areas for pioneer and/or climax plant species.
- Generate maps showing locations of areas infested with exotic invasive plant species, and record rare, native plants as well.
- Characterize the biodiversity of the BORCE.
- Identify new natural areas and/or sensitive plant communities.
- Collect and prepare plant herbarium specimens for a permanent record of taxa.
- Determine in an ecological sense, if native plant species are being overtaken and being out-competed by invasive plant species. Are we losing populations of native plants to the invaders?
- Continued mapping, monitoring and reconnaissance of invasive and native plant species on the BORCE.

- Rank invasive plant infestations in the field (scale of 1-5, with number 1 being “few plants observed”, to the other extreme of number 5 being “area totally infested”). Note that Figures 3-5 show BORCE exotic plant infestation areas.

Methods and Materials

The focus of this monitoring program was to identify exotic invasive plant infestation sites as well as native plant species on the entire 3,000 acres of the BORCE. Approximately 100 field stations (mini-plots) were collected during 2004 as activities commenced in June and concluded in late October. Since the project inception in 2003 and continuing until the present, approximately 350 total field survey stations (mini-plots) have been recorded. Each field station (mini-plot) is defined as a 50-foot circle from center point or circumference (GPS location taken at the center point). As many plant species as possible within the mini-plot were identified (common names & corresponding scientific names). Canopy, sub-canopy, shrub, herbaceous, and groundcover plant species were listed on the field survey sheets. Field mapping of native and invasive plant species on the 3,000 acres began by first surveying the available roads and trails with individual field stations (mini-plots) on a 200 meter grid interval. All mini-plots plus unusual or rare plant population locations (if encountered between mini-plot intervals), were mapped with a Garmin etrex™ GPS hand-held unit, and coordinates saved for future reference. All field data was recorded on field survey sheets at each mini-plot location and later placed on a Microsoft Excel ™ spreadsheet database. Maps will be prepared with MapInfo™ GIS software to show locations of all field stations, invasive and rare plant locations, geologic features and other pertinent topographical information. Ultimately, plant species maps will be generated to show locations of the major exotic infestation sites.

Roads and trails were mapped first, then transects were walked in the backcountry of the BORCE (similar to a “timber cruise”) in generally north to south traverses. Later, east-west traverses were traversed in the backcountry to complete a grid pattern of coverage over the parcel. Unfortunately, mobility and access problems with dead stands of diseased pines caused considerable deviations in field traverses even while on foot. Still, good field coverage was achieved during both the 2003 and 2004 field seasons on the EBOR and McKinney Ridge sections. Several field forays were initiated in 2004 on the WBOR, but considerable fieldwork remains to be completed in this section during the 2005 field season. Additionally, natural geological and topographical features such as faults, rock outcroppings, springs, sinkholes and caves will be mapped.

The Kodak EasyShare™ 7430 digital camera was used to document plant species in the field as well as pre-Manhattan cultural/historical features of the former Wheat community. Karst and geologic features such as springs, seeps, sinkholes, and caves were also logged and located with the Garmin etrex™ GPS unit. The boundaries of the pine deadfall areas were mapped whenever possible in the field. These sites may become important ecological study areas to determine if native climax species or invasives will re-establish here. Ecology of the infested sites, including competition between established native species and invaders, and pine deadfall areas will be evaluated as to recovery and establishment of climax plant species. Are native plant species being out-competed by the invaders?

No analytical sampling of plant species is envisioned for this project. However, plant species will be collected for preparation and preservation as herbarium specimens. The sample will be collected as much as possible with either flower or fruit then pressed and dried, and mounted on herbarium paper with appropriate identification labels. These are quite useful for training purposes but more importantly to document and confirm the presence of plant species (especially rare species) encountered in the field. Care will be taken to not over-sample sensitive plant communities.

Field data sheets (field survey logs) were recorded for each field station and later placed in a Microsoft Excel™ spreadsheet database. Maps will be prepared with MapInfo™ GIS software to show locations of all field stations, invasive and rare plant locations, geologic features, and other pertinent topographical information. Ultimately, plant species maps will be generated to show locations of the major exotic infestation sites.

Results and Findings

During the 2003 and 2004 field seasons, approximately 350 field data stations (See Figure 2) were inventoried (and database developed) per the methodology described under the "Methods and Materials" section. The main areas covered during 2003/2004 were the East Blackoak, McKinney and small portions of the West Blackoak tracts (See Figure 1). It is estimated that approximately 1,800 acres of the 3,000 total BORCE acres have been covered to this point. Several exotic plant infested areas were identified on the East Blackoak Ridge tract. Some of the main pest plants identified so far infesting areas of Blackoak Ridge include: (1) Privet (*Ligustrum spp*. L.), (2) Nepalgrass (*Microstegium vimineum*), (3) Autumn Olive (*Elaeagnus umbellata*), (4) Kudzu (*Pueraria montana*), (5) Wild Yam (*Dioscorea bulbifera* or *D. batatas*), (6) Bush Honeysuckle (*Lonicera maackii*), (7) Japanese Honeysuckle (*Lonicera japonica*), and (8) Tree-of-Heaven (*Ailanthus altissima).* Figure 3 is an example of a plant density map (thematic map) demonstrating areas infested with Kudzu and Privet plants on the EBOR section. Please note that the "**dark-shaded circles**" on the map represent Kudzu infested areas, "**lighter-shaded circles**" represent Privet infested areas, and the small "stars" represent field inventory stations (survey data points).

Figures 4 and 5 show exotic plant infested areas of McKinney Ridge and the WBOR, which were field mapped primarily during 2004, and as such, the figures summarize the data collected. The "**dark stars"** represent exotic plants while the **"circles-with-triangles"** represent rich vascular plant sites (includes T & E plants). There is considerable fieldwork to be completed during the 2005-06 field seasons on the remaining 1,200 acres of the WBOR and McKinney Ridge sections of the BORCE. So, the total botanical picture of the BORCE site is still unclear and yet to be completed. Summarizing the 2004 data:

WBOR / McKinney Ridge Exotic Invasive Plant Taxa:

- Privet (*Ligustrum spp*. L.),
- Nepalgrass (*Microstegium vimineum*)
- Kudzu (*Pueraria montana*)
- Wild Yam (*Dioscorea bulbifera* or *D. batatas*)
- Bush Honeysuckle (*Lonicera maackii*)
- Japanese Honeysuckle (*Lonicera japonica*)

- Queen Anne Lace (*Daucus carota*)
- Tree-of-Heaven (*Ailanthus altissima)*
- Crown Vetch (*Coronilla varia*)

WBOR / McKinney Ridge Vascular Plant Taxa (including Rare/T & E Taxa):

- Goldenseal (*Hydrastis Canadensis*) TDEC-listed as "S-CE"
- Spreading False Foxglove (Aureolaria patula) TDEC-listed as "T"
- Appalachian Bugbane (*Cimicifuga rubifolia*) TDEC-listed as "T"
- Pink Lady Slippers (*Cypripedium acaule*) TDEC-listed as "E-CE"
- Hemlock/Rhododendron Boreal Forest (*Tsuga sp./Rhododendron sp*.)
- Showy Orchis (*Galearis spectabilis*)
- Ginseng (*Panax quinquefolius*) TDEC-listed as "S-CE"
- Biodiverse Fern Colonies (Pteridophytes)

The TDEC Division of Natural Heritage's (DNH) mission is to restore and protect the biodiversity of Tennessee through several programs (i.e., Rare Species Protection Program) and also administers the Rare Plant Protection and Conservation Act of 1985 in cooperation with the U.S. Fish and Wildlife Service. This act directs that the DNH develop a state list of threatened, endangered ("T & E Species"), and special concern plants concerning rare plant conservation. The following is a list of DNH "State Status" definitions concerning T & E Species:

"**E**" = **Endangered Species**: Means any species or subspecies of plant whose continued existence as a viable component of the state's flora is determined by the Commissioner to be in jeopardy, including but not limited to all species of plants determined to be a "threatened species" pursuant to the Endangered Species Act.
"**CE**" = **Commercially Exploited**: Due to large numbers of plants being taken from the wild and propagation or cultivation insufficient to meet market demand. These plants are of long-term conservation concern, but the DNH does not recommend they be included in the normal environmental review process.
"**E-CE**"= **Endangered-Commercially Exploited**
"**S-CE**"= **Special Concern Species-Commercially Exploited**
"**S**" = **Special Concern Species**: Means any species or subspecies of plant that is uncommon in Tennessee, or has unique or highly specific habitat requirements or scientific value and therefore careful monitoring of its status.
"**T**" = **Threatened Species**: Means any species or subspecies of plant which appears likely, within the foreseeable future, to become endangered throughout all or a significant portion of its range in Tennessee, including but not limited to all species of plants determined to be a "threatened species" pursuant to the Endangered Species Act.

Conclusions

Field-mapping activities will resume in spring 2005 and it is anticipated that approximately 6-12 field days will be required for field botany surveys and involve between 90-180 man-hours (two field staff). The 2005 field work will focus on the WBOR plus some small areas of the McKinney Ridge section of the EBOR that require further botanical coverage to determine if there are additional areas infested with exotic plants. Rare plant taxa will continue to receive priority for field location and identification.

From the initial mapping efforts during 2003/2004, we have observed that the majority of the exotic species occur along existing gravel roads, pine-beetle damaged pine plantations, and formerly disturbed sites, where the exotics have little competition for habitat space. Examples of exotic pest plants cataloged on the BORCE during 2003/2004 include: (1) Privet (*Ligustrum spp*. L.), (2) Nepalgrass (*Microstegium vimineum*), (3) Autumn Olive (*Elaeagnus umbellata*), (4) Kudzu (*Pueraria montana*), (5) Wild Yam (*Dioscorea bulbifera* or *D. batatas*), (6) Bush Honeysuckle (*Lonicera maackii*), (7) Japanese Honeysuckle (*Lonicera japonica*), and (8) Tree-of-Heaven (*Ailanthus altissima).* Of these taxa, it is important to note that based on field work completed to date, three species appear to present the worst case scenario for invasions on the BORCE: Privet, Kudzu, and Nepal Grass. In the case of kudzu infestations, it does not seem to matter about competition from native plants as this aggressive invader takes over all vegetation (living or dead), open space, etc. There are numerous acres of kudzu-infested locations in the backcountry (off-road/off-trail areas).

Figures 6 and 7 are images of a kudzu-infested location and, then, the rare spreading false foxglove flowers (respectively) as found on the BORCE.

Biodiversity Noted on the BORCE:

- Located several *Castanea dentata* sprouts (some to 20 feet in height)
- Numerous locations of *Rhododendron cumberlandense*
- Additional Boreal Forest sites observed
- Several Fern-rich (Pteridophytes) community sites located

Sampling protocol and quality control methods followed the guidelines in the division's *"Standard Operating Procedures"* and *"Health, Safety, and Security Plan."* Sampling teams consisted of two EMC staff that located the plants and collected the prescribed number of field data points. Field personnel wore appropriate light-colored, warm weather clothing and used insect repellant to ward off ticks. Also, pant legs were taped to deny ticks entry to the lower extremity area of the body. Snake chaps were worn in thick, high brush areas since venomous snakes are native to our region. Field teams were also cognizant of stinging insects such as yellow-jacket and hornet nests. Finally, field teams were aware of various other field hazards such as slips, trips and falls, plus the danger of lightning due to summer thunderstorms.

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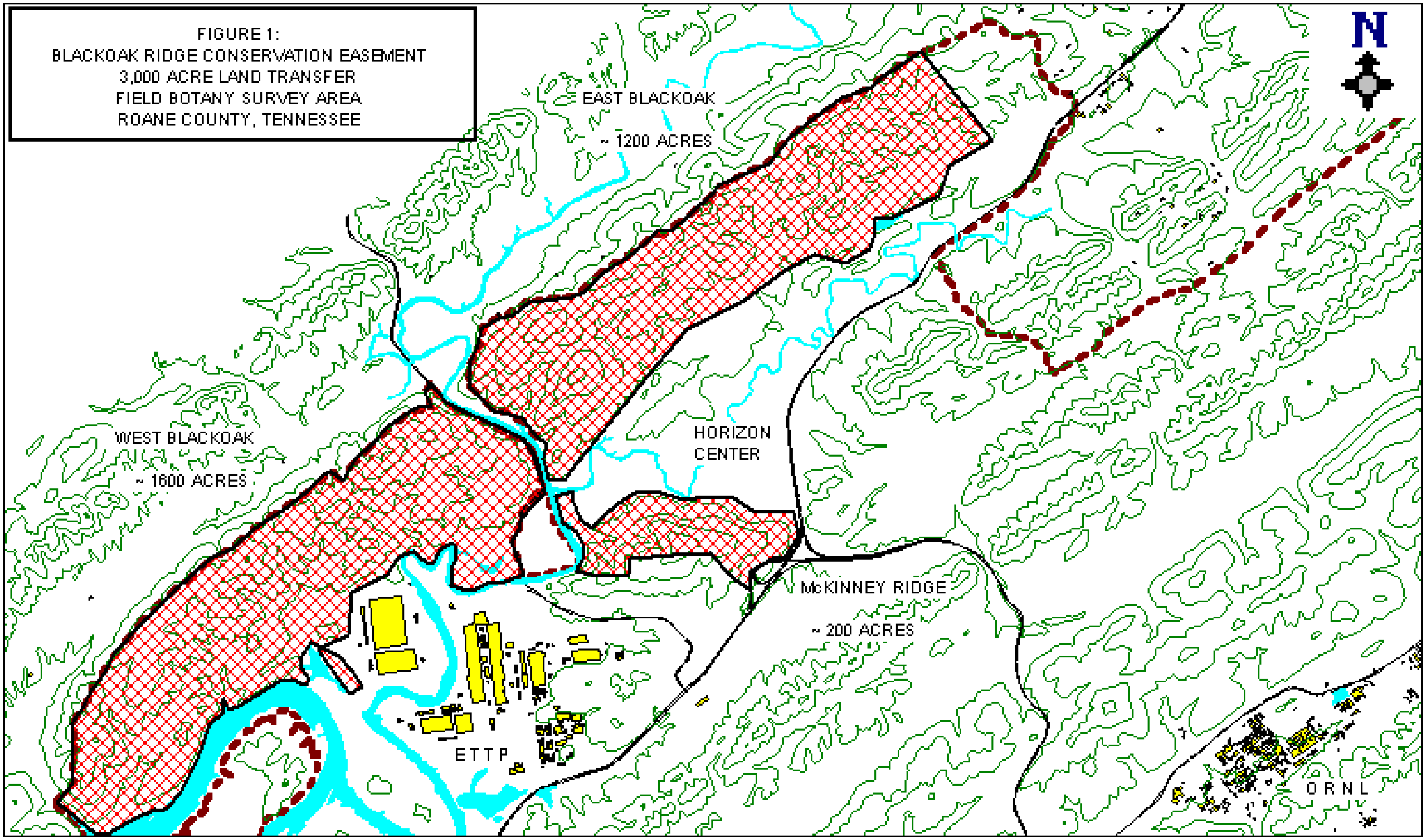


FIGURE 1:
BLACKOAK RIDGE CONSERVATION EASEMENT
3,000 ACRE LAND TRANSFER
FIELD BOTANY SURVEY AREA
ROANE COUNTY, TENNESSEE
N
EAST BLACKOAK
~ 1200 ACRES
WEST BLACKOAK
~ 1600 ACRES
HORIZON
CENTER
McKINNEY RIDGE
~ 200 ACRES
ETTP
ORNL

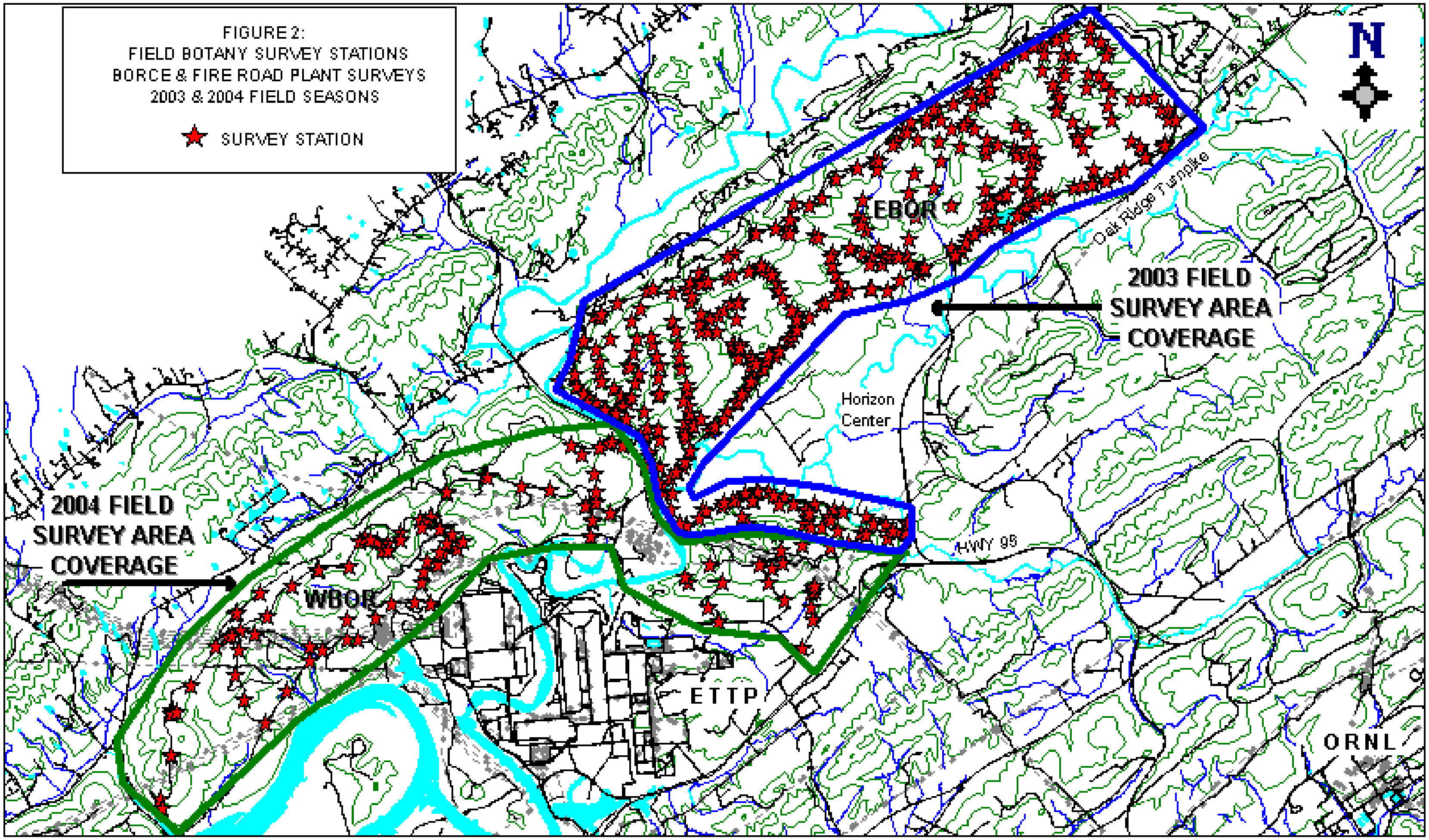


FIGURE 2:
FIELD BOTANY SURVEY STATIONS
BORCE & FIRE ROAD PLANT SURVEYS
2003 & 2004 FIELD SEASONS
SURVEY STATION
N
EBOR
2003 FIELD
SURVEY AREA
COVERAGE
Oak Ridge Turnpike
Horizon
Center
2004 FIELD
SURVEY AREA
COVERAGE
WBOR
HWY 95
ETTP
ORNL

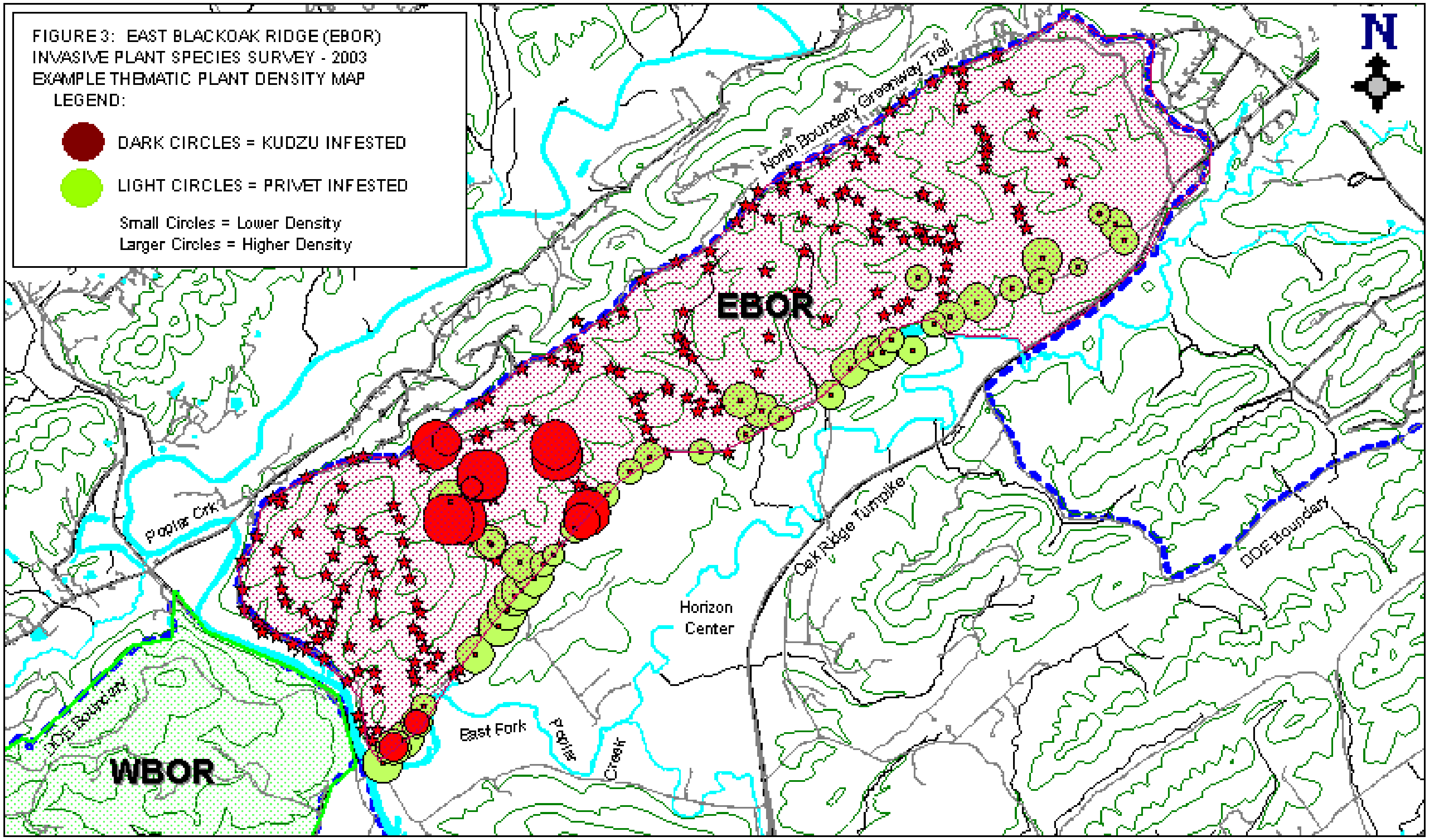
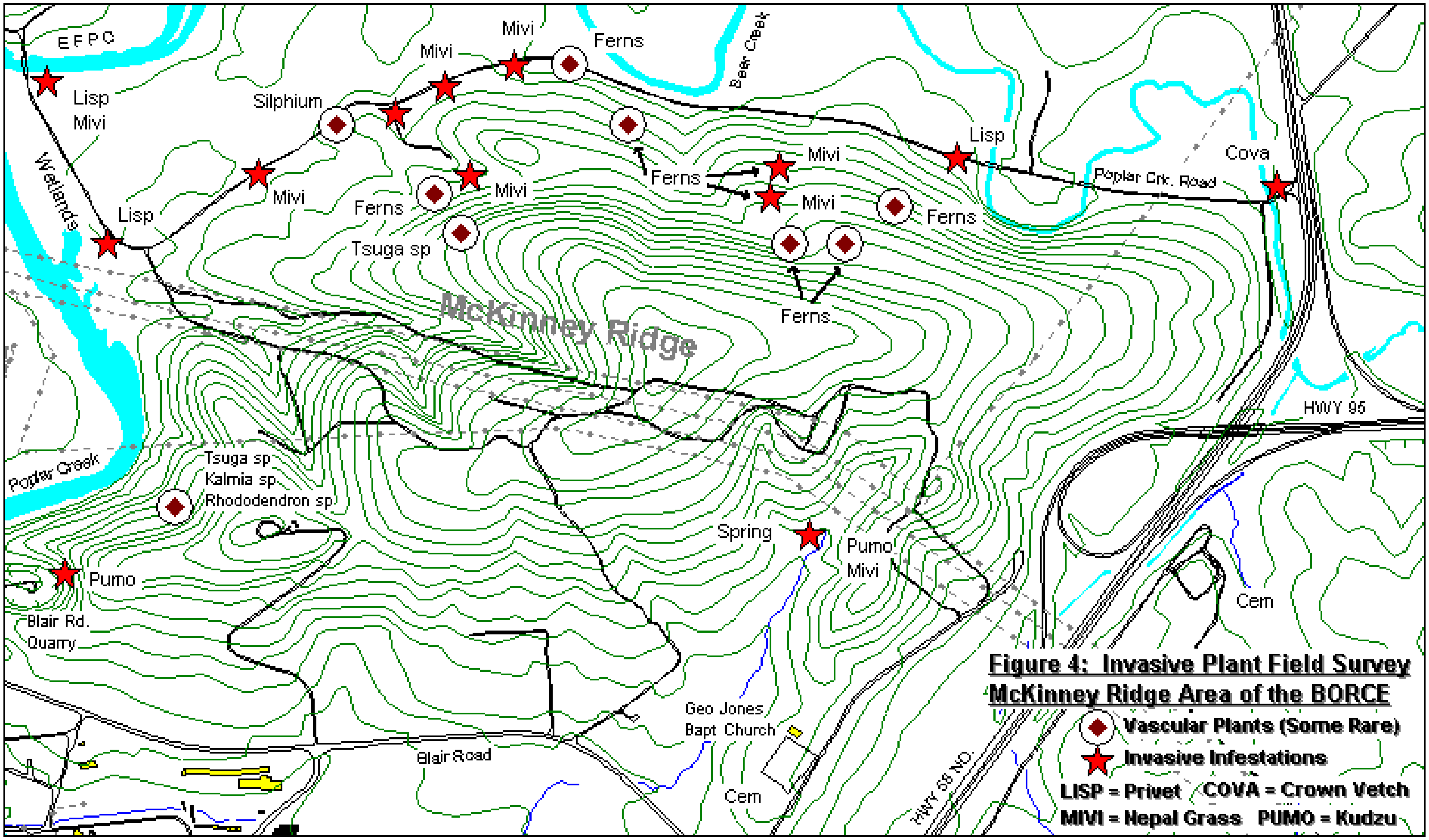


FIGURE 3: EAST BLACKOAK RIDGE (EBOR)
INVASIVE PLANT SPECIES SURVEY - 2003
EXAMPLE THEMATIC PLANT DENSITY MAP
LEGEND:
DARK CIRCLES = KUDZU INFESTED
LIGHT CIRCLES = PRIVET INFESTED
Small Circles = Lower Density
Larger Circles = Higher Density
N
North Boundary Greenway Trail
EBOR
Poplar Crk
Oak Ridge Turnpike
DOE Boundary
Horizon
Center
East Fork
Poplar
Creek
DOE Boundary
WBOR



EFPC
Lisp
Mivi
Wetlands
Lisp
Silphium
Mivi
Mivi
Mivi
Ferns
Beer Creek
Ferns
Mivi
Tsuga sp
Ferns
Mivi
Ferns
Mivi
Ferns
Lisp
Poplar Crk. Road
Cova
Ferns
McKinney Ridge
Poplar Creek
Tsuga sp
Kalmia sp
Rhododendron sp
Pumo
Blair Rd.
Quarry
Spring
Pumo
Mivi
HWY 95
Cem
Geo Jones
Bapt Church
Blair Road
Cem
HWY 58 NO.
Figure 4: Invasive Plant Field Survey
McKinney Ridge Area of the BORCE
Vascular Plants (Some Rare)
Invasive Infestations
LISP = Privet
COVA = Crown Vetch
MIVI = Nepal Grass
PUMO = Kudzu

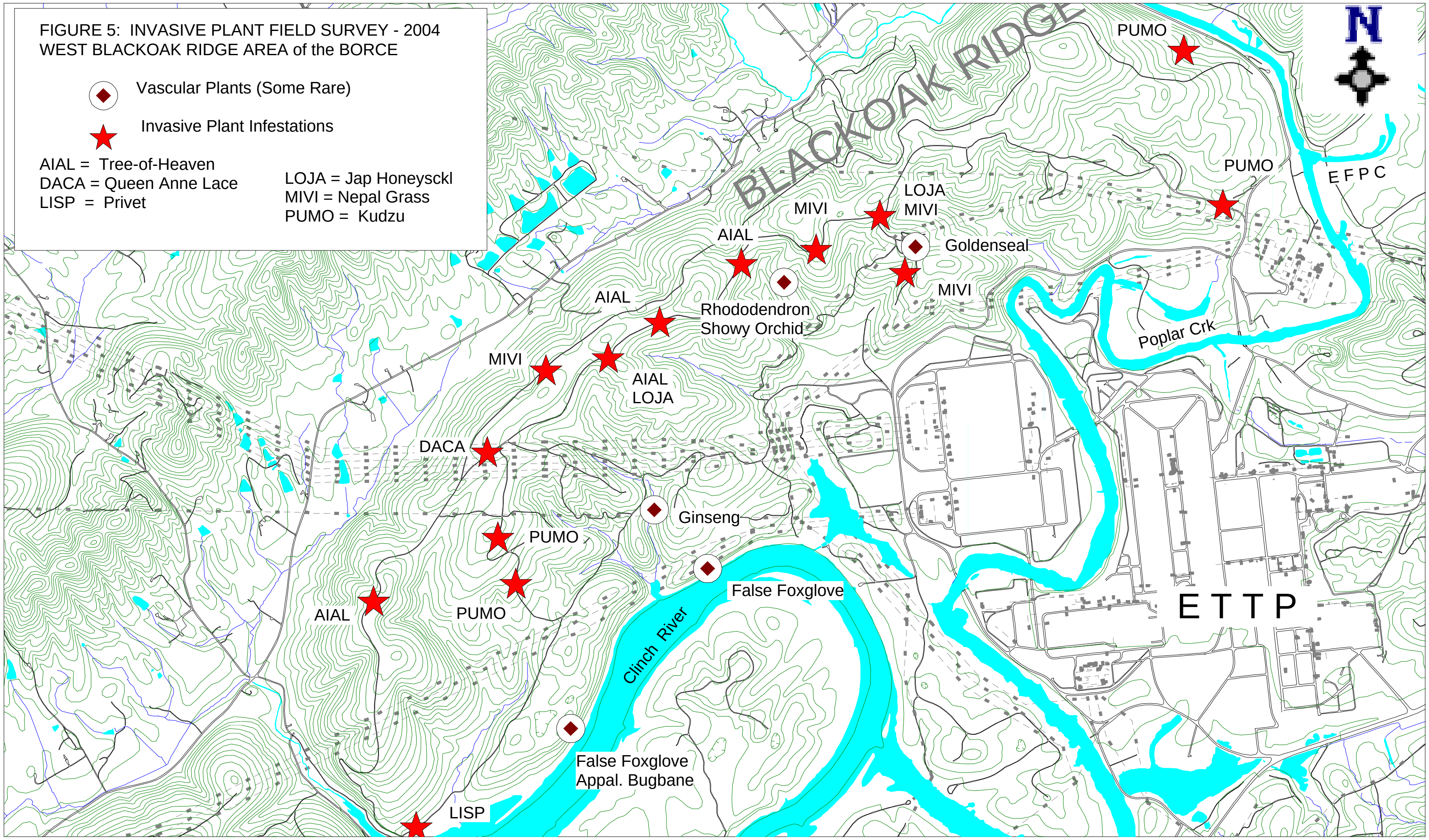


FIGURE 5: INVASIVE PLANT FIELD SURVEY - 2004
WEST BLACKOAK RIDGE AREA of the BORCE

FIGURE 6: KUDZU INFESTATION – WEST BLACKOAK RIDGE (ETTP)

FIGURE 7: FALSE FOXGLOVE – EAST BLACKOAK RIDGE (NO. OF ED-1)

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CHAPTER 5 <u>RADIOLOGICAL MONITORING</u>

Facility Survey and Infrastructure Reduction Program

Principal Author: David Thomasson

<u>Abstract</u>

Like other Department of Energy research facilities across the nation, the Oak Ridge Reservation released large quantities of chemical and radiological contamination into the surrounding environment during nearly five decades of nuclear weapons research and development. In response to this history, the Tennessee Department of Environment and Conservation's Department of Energy Oversight Division (the division) developed a Facility Survey Program to document the histories of facilities on the Reservation. The survey program assesses facilities' physical condition, inventories of hazardous chemical and radioactive materials, process history, levels of contamination, and present-day potential for release of contaminants to the environment under varying conditions ranging from catastrophic (i.e. tornado) to normal everyday working situations. This broad-based assessment supports the objectives of Section 1.2.3 of the *Tennessee Oversight Agreement*, which was designed to inform local citizens and governments of the historic and present-day character of all operations on the Reservation. This information is also essential for local emergency planning purposes. Since 1994 the division's survey team has characterized 172 facilities and found that thirty-five percent pose a relatively high potential for release of contaminants to the environment. In many cases, this high-potential-for-release is related to legacy contamination that escaped facilities through degraded infrastructures over decades of continual industrial use (e.g. leaking underground waste lines, substandard sumps and tanks, or ventilation ductwork). Since the inception of the program, DOE corrective actions (including demolitions) have removed twelve facilities from the division's list of "high" Potential Environmental Release (PER) facilities. In 2004, two facilities (K-1025-A, K-1025-B) were removed through demolition.

Beginning in 2002 the Facility Survey Program staff began refocusing its primary effort on the oversight of facilities slated for demolition at ORNL and Y-12. This activity was in response to formal, accelerated infrastructure reduction (demolition) programs at each of those sites. Staff completed organized document reviews and field oversight of all activities related to facility demolition. During 2004 staff made 463 field visits before and during the demolition of 38 facilities.

<u>Introduction</u>

The Tennessee Department of Environment and Conservation's Department of Energy Oversight Division (the division), in cooperation with the Department of Energy (DOE) and DOE contractors, conducts a Facility Survey Program (FSP) on the Oak Ridge Reservation (ORR). The program provides a comprehensive independent assessment of active and inactive facilities on the reservation based on their: (1) physical condition (2) inventories of radiological materials and hazardous chemicals (3) levels of contamination; and (4) operational history. The ultimate goal of the program is to fulfill the commitments agreed to by the state of Tennessee and the Departmentof Energy in Section 1.2.3 of the Tennessee Oversight Agreement, which states that *"Tennessee will pursue the initiatives in attachments A, C, E, F, and G. The general intent of these action items is to continue Tennessee's: (1) environmental monitoring, oversight and environmental restoration programs; (2) emergency preparedness programs; and (3) delivery of a* *better understanding to the local governments and the public of past and present operations at the ORR and potential impacts on the human health and/or environment by the ORR."* **The overall objective of the Facility Survey Program is to provide a detailed assessment of all potential hazards affecting or in any way associated with facilities on the Oak Ridge Reservation.** To this end, the program evaluates facilities' potential for release of contaminants to the environment under varying environmental conditions ranging from catastrophic (i.e. tornado, earthquake) to normal everyday working situations. This information is also essential for proper emergency preparedness planning.

Methods, Materials and Evaluating the Potential for Environmental Release (PER)

Survey program staff takes a historical research approach to evaluating each facility. Prior to commencing fieldwork they examine engineering documents, past contaminant release information, hazard-screening documents, drain databases, and radiological and chemical inventory data. They then perform a walk-through of the facility with the facility manager to gather additional information and to validate previously reviewed documents. During the walk-through, calibrated radiation survey instruments are used to estimate radiation contamination and dose levels. At the end of the document review and walk-through process, a final report is produced and information is entered into the division's Potential for Environmental Release (PER) database. This database helps the team characterize conditions at each facility based on its physical condition and potential for release of contaminants to the environment.

The PER database is composed of 10 "categories" that relate directly to the contents and condition of the operational infrastructure within and around each facility (Table 1). Each category is assigned a score from 0 to 5 (5 reflects the greatest potential) for each of the 10 "categories" (Table 2). As facilities are scored, totaled, and compared with each other, a relative ranking emerges. Special circumstances, such as legacy releases and professional judgment also influence category scoring. Scores are **not intended to reflect human health risk.** Rather, their sole purpose is to characterize facilities based on the conditions in and around them. This information is used within the division for information, comparison, and review purposes only.

The final facility survey report notifies DOE of the division's findings so that DOE has the opportunity to respond and formulate corrective actions. When the division receives written confirmation from DOE of corrective actions taken on a specific facility, the ranking for that facility is modified accordingly. The 10 "categories" that are scored and the "scoring criteria" are presented below in Tables 1 and 2. Table 3 provides a program summary.

Table 1: Categories to be Scored

1.	Sanitary lines, drains, septic systems
2.	Process tanks, lines, and pumps
3.	Liquid Low-level Waste tanks, lines, sumps, and pumps
4.	Floor drains and sumps
5.	Transferable radiological contamination
6.	Transferable hazardous materials contamination
7.	Ventilation ducts and exit pathways to create outdoor air pollution
8.	Ventilation ducts and indoor air/building contamination threat
9.	Radiation exposure rates inside the facility escalated
10.	Radiation exposure rates outside the facility escalated

Table 2: Potential Environmental Release Scoring Guidelines

Score	Score is based on observations in the field and the historic and present-day threat of contaminant release to the environment/building and/or ecological receptors.
0	**No potential**: no quantities of radiological or hazardous substances present.
1	**Low potential**: minimal quantities present, possibility of an insignificant release, very small probability of significant release, modern maintained containment.
2	**Medium potential**: quantities of radiological or hazardous subs. present, structures stable in the near to long term, structures have integrity but are not state-of-the-art, adequate maintenance.
3	**Medium potential**: structures unstable, in disrepair, containment failure clearly dependent on time, integrity bad, maintenance lacking, containment exists for the short term only.
4	**High potential**: quantities of radiological or hazardous subs. present. Containment for any period of time is questionable; migration to environment has not started.
5	**Release**: radiological or hazardous substance containment definitely breached, environmental/interior pollution from structures detected, radiological and/or hazardous substances in inappropriate places like sumps/drains/floors, release in progress, or radiological exposure rates above Nuclear Regulatory Commission (NRC) guidance.
Note: A score of 0 or 1 designates a low Potential Environmental Release rank; a score of 2 or 3 designates a moderate rank; a score of 4 or 5 designates a high rank.	

Discussion and Results

The Facility Survey Program entered its eleventh year in January 2004. As in previous years, inter-agency staff cooperation was excellent; this facilitated the flow of information related to corrective actions, changes in facility status or mission, decommissioning and decontamination activities, and onsite professional activities. During 2004 the survey program's Y-12 representative spent approximately one half of his time at the Y-12 site. This presence greatly enhanced program activities at that site.

In accordance with past division policy, an individual survey conducted on a facility at K-25 that has been leased to private industry might only address those portions of the facility that are leased. Consequently, some older reports may not include adjacent areas in the same facility or related facilities. These adjacent areas and related facilities may be contaminated and/or exhibit safety problems that are not reflected in the report. Therefore, when reviewing these reports, it is important to look for the phrase "leased area of the facility." This phrase indicates that the survey report covers only the leased area of the facility, specifically, and is not intended to assess the entire facility or related facility problems (such as drain lines) that may exist outside of the leased area.

Since program staff is continually in the process of evaluating DOE corrective actions taken to address facility concerns, any current ranking may not reflect the most recent corrective actions. Since the inception of the FSP, corrective actions (including demolition) have removed twelve facilities (X-3525, X-7823-A, X-7827, X-7819, X-3505, K-1098-F, K-1200-C, Y-9404-3, Y-9208, Y-9620-2, K-1025-A, K-1025-B) from the division's list of "high" Potential Environmental Release facilities.

Table 3: Facility Survey Program Summary

	Totals	High PER Facilities	Removed High PER	Facilities Resurveyed	Demolition Visits
A.: Facilities surveyed 1994	15	9	0	0	0
B.: Facilities surveyed 1995	35	11	0	0	0
C.: Facilities surveyed 1996	34	9	0	0	0
D.: Facilities surveyed 1997	23	8	0	0	0
E.: Facilities surveyed 1998	8	3	1	2	0
F.: Facilities surveyed 1999	14	3	0	0	0
G.: Facilities surveyed 2000	14	5	3	0	0
H.: Facilities surveyed 2001	17	8	1	1	0
I.: Facilities surveyed 2002	8	5	5	0	90
J.: Facilities surveyed 2003	4	4	0	0	236
K.: Facilities surveyed 2004	0	0	2	1	463
K.: Totals	**172**	**61**	**12**	**4**	**789**

Description of the 49 Highest Scoring Facilities (1994-04)
The PER database attempts to reflect the overall condition of a facility and the potential for environmental release. However, it is not the total score of the 10 categories that is always the best indicator of potential for environmental release. Rather, what appears to be the most accurate indicator is the number of categories for which a facility scores a four or five (Table 1). Of the 172 facilities scored since 1994, 61 stood-out with one or more categories scoring a four or five (Table 4). Twelve of these facilities have been removed through corrective actions or demolition. The following 56 high-scoring facilities are arranged in descending order of total numbers of fours and fives in the PER database.

Table 4: Potential for Environmental Release for 56 High Scoring Facilities

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
	DRAIN	TANKS	TANKS	SUMPS	TRANSF	TRANSF	VENT TO	VENT	INT. EXP.	O. EXP.	NUMBER	SURVEY
	LINES	LINES	LINES	DRAINS	RAD.	HAZ.	OUTSIDE	INSIDE	RAD.	RAD.	OF	YEAR
BUILDING	SANI.	PROC.	LLLW	FLOOR	CONT.	CONT.	AIR	SYSTEM	SURVEY	SURVEY	4 and 5's	
X3028	0	4	4	3	4	4	4	5	5	3	7	1997
Y9731	4	5	1	4	3	5	5	5	3	2	6	2003
K1037-C	0	0	0	0	5	5	5	5	5	4	6	1998
9401-2	1	4	1	4	1	5	4	4	1	0	5	2001
Y9204-3	3	5	2	3	4	5	4	4	2	1	5	2000
X3019-B	2	2	5	3	2	3	4	4	4	4	5	1995
K633	3	5	1	4	5	5	2	5	4	5	5	2002
K1004-B	5	0	0	5	2	5	2	5	2	0	4	2001
K1004-A	5	0	0	5	2	5	2	5	2	0	4	2001
X7700	4	0	0	3	5	4	2	2	3	5	4	1996
X7700C	4	4	0	4	2	1	2	0	0	4	4	1996
Y9201-4	2	5	0	2	2	4	5	5	2	1	4	1998
K1015	5	0	5	0	5	5	2	2	2	1	4	2002
K1004-J	5	5	0	4	3	0	0	0	1	1	3	2000
Y9203	4	2	0	4	2	4	2	2	2	0.5	3	1995
X2545	0	3	5	0	4	2	3	0	0	4	3	1995
K1200-C	1	3	0	1	3	5	2	4	3	4	3	1995
Y9769	1	1	0	4	4	2	1	2	4	2	3	1995
X3020	0	0	5	5	5	0	2	0	0	1	3	1997
X3108	0	0	5	5	5	0	2	2	2	2	3	1997
X3091	0	0	5	5	5	1	2	2	3	2	3	1997
K1004-E	5	0	0	5	2	5	3	0	2	0	3	2002
Y9616-3	0	2	0	4	2	4	1	1	1	1	2	2002
Y9738	2	0	0	4	2	4	1	1	2	1	2	2002
Y9743-2	0	3	0	5	3	5	2	2	2	1	2	2001
X3592	0	3	3	2	4	4	3	3	3	2	2	2001
X3504	1	3	0	4	5	0	2	1	2	2	2	2001
X2531	1	1	2	1	5	2	2	1	2	4	2	2001
Y9213	3	1	5	3	3	5	1	1	1	1	2	2000
X7720	0	0	0	0	4	0	0	0	0	4	2	1996
X3001	3	1	2	3	3	2	4	4	3	3	2	1995
K1200-S	2	3	0	3	3	2	3	4	2.5	4	2	1995
X7701	4	3	0	4	2	0	2	0	0	3	2	1996
X7706	4	3	0	4	2	0	2	2	2	2	2	1996
X7707	4	0	0	4	2	3	2	2	0	0	2	1996
Y9736	0	0	0	0	0	4	2	3	0	0	1	2003
Y9959-2	0	0	0	0	1	4	0	0	1	0	1	2003
Y9959	0	0	0	0	1	4	0	0	1	0	1	2003

Table 4: Potential for Environmental Release for 55 High Scoring Facilities cont'd

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
	DRAIN	TANKS	TANKS	SUMPS	TRANSF	TRANSF	VENT TO	VENT	INT. EXP.	O. EXP.	NUMBER	SURVEY
	LINES	LINES	LINES	DRAINS	RAD.	HAZ.	OUTSIDE	INSIDE	RAD.	RAD.	OF	YEAR
BUILDING	SANI.	PROC.	LLLW	FLOOR	CONT.	CONT.	AIR	SYSTEM	SURVEY	SURVEY	4 and 5's	
X3085	1	4	3	3	3	2	1	2	3	3	1	1994
X7602	0	2	0	2	4	2	1	3	2	1	1	1997
K1220-N	0	2	0	0	3	2	2	4	2	3	1	1995
X3002	0	2	0	2	3	1	2	3	4	1	1	1996
Y9210	1	0	0	4	1	1	1	2	1	0	1	1995
Y9224	1	0	0	4	1	1	1	2	1	0	1	1995
Y9211	1	0	0	4	1	1	1	2	1	0	1	1995
Y9207	2	0	0	1	1	4	3	1	1	0	1	1995
X7055	0	0	0	4	0	1	1	1	0	0	1	1997
X7700-B	0	0	0	0	3	0	2	0	0	4	1	1996
K1401-L3	1	0	0	1	4	2	1	2	3	1	1	1997
Y9201-3	2	1	0	2	3	5	2	2	2	1	1	1999
*X7819	0	0	0	0	0	0	0	0	0	0	0	1994
*****X3505	0	0	0	0	0	0	0	0	0	0	0	2000
*Y9620-2	0	0	0	0	0	0	0	0	0	0	0	1994
*Y9208	0	0	0	0	0	0	0	0	0	0	0	1995
*Y9404-3	0	0	0	0	0	0	0	0	0	0	0	1994
*K1025-A	0	0	0	0	0	0	0	0	0	0	0	1995
*K1025-B	0	0	0	0	0	0	0	0	0	0	0	1996

* Denotes demolished facility

At **Y-12** eighteen facilities had at least one category score of 4 or 5: 9731, 9204-3, 9201-4, 9401-2, 9213, 9743-2, 9203, 9769, 9201-3, 9616-3, 9738, 9210, 9224, 9211, 9207, 9959, 9736, and 9959-2.

Facility Y-9731 is the oldest facility in the Y-12 complex. It originally housed the pilot project for the prototype calutron, and the original production facilities for stabilized metallic isotopes, which were used in nuclear medicine. It received four category scores of 5, two category scores of 4, and a total of 37. Most of the facility (outside the office area) today is not receiving preventative maintenance. Process tanks and lines have leaked radiological and hazardous materials throughout the building. Asbestos-containing pipe insulation is peeling and flaking, as is lead-bearing interior and exterior paint. The exhaust fans for the building are not HEPA filtered, and therefore pose a direct pathway to the environment.

Facility Y-9204-3 (Beta 3) is one of the original isotope enrichment facilities at Y-12. It received two category scores of 5, three category scores of 4, and a total score of 33. This 250,000sq. ft. facility is now inactive and locked. The largest concerns are leaking PCB-contaminated mineral oil (Z-oil), and radiological contamination. The building has not been sampled above eight feet for radiological contamination, even though the probability of finding it is great. The building historically and presently vents directly to the environment without HEPA filtration.

Facility Y-9201-4 (Alpha 4) is also one of the original Y-12 uranium enrichment buildings. It received three category scores of 5, one category score of 4, and a total of 28. The containment integrity of the original process system is weak. This has resulted in breaches that have deposited contaminants in unwanted places throughout the building. Evidence suggests that open (non-filtered) exhaust fans have also released contaminants from the interior of the building to the environment for decades. PCBs, asbestos insulation, and chipping/flaking lead-based paint are also found deposited throughout the building.

Facility Y-9401-2 (Plating Shop) received four category scores of 4, one category score of 5, and a total of 25. All of these scores relate to a variety of chemical contamination issues.

Facility Y-9213 (Criticality Experiment Facility) received two category scores of 5, and a total of 24. This facility was built in 1951 and contains two underground neutralization tanks and an underground pit. The tanks and pit present a very high potential for radiological and chemical soil contamination. The areas around the tanks have not been sampled for contamination. The facility also exhibits extensive flaking of exterior lead-based paint.

Facility Y-9743-2 (Animal Quarters) received two category scores of 5, and a total of 20. These scores reflect the uncertainty associated with the lack of radiological and chemical sampling surveys, the complete lack of institutional and process knowledge and, the fact that there are interior tanks and bottles with unknown contents. The probability of biological and chemical contamination is high. There is also a total lack of facility maintenance.

Facility Y-9203 (Instrumentation, Characterization Department and Manufacturing Technology Development Center) has three category scores of 4 and a total score of 22.5. Despite much work that has been done to re-route process drains from terminating in the storm sewer system, these drains now go to the sanitary sewer system. This termination still presents a potential pathway to the environment and the public.

Facility Y-9769 (Analytical Services Organization) has three category scores of 4 and a total score of 21. The primary hazards associated with this facility are related to the wide variety of toxic materials maintained in the laboratory and the building's drain destination. Exit drains go to the Oak Ridge Sewage Treatment Facility and therefore represent a pathway for contaminants to the city's effluent and/or sludge. Also, the sub-basement area is posted as a contamination area and confined space. Failure of containment could cause a release to East Fork Poplar Creek or to the atmosphere.

Facility Y-9201-3 (Alpha 3) received one category score of 5, and a total of 20. This facility is not receiving any maintenance on its exterior painted surface. Lead based paint is chipping and is being spread extensively around the building.

Facility Y-9616-3 received two category scores of 4 because of extensive interior and exterior peeling lead-based paint, and degraded asbestos-containing wall coverings and pipe insulation. The building is not receiving maintenance. There is a serious loss of process knowledge.

Facility Y-9738 received two category scores of 4, and a total of 17. This building contains foundry machinery and furnaces and spaces that are chemically and radiologically contaminated from past operations. It is assumed that some of this material has moved into the floor drain system. There is also extensive exterior paint peeling. There was a very limited knowledge of process history available to staff.

Facilities Y-9210, Y-9211, Y-9224 (ORNL Biology) each had one category score of 4 with a total score of 11 for each facility. The original concern regarding each of these facilities was the questionable terminal destinations of their exit drains, which in some cases historically went to the storm sewer system. Written confirmation from the DOE contractor has since shown the correct terminations and corrective actions taken on some of these drains, but there are still undefined and/or inappropriate drain terminations (i.e. lab drains that terminate at the sanitary sewer).

Facility Y-9207 Biology Complex received one category score of 4, and a total score of 13. In this facility the sinks in a radiological area drain directly to the Oak Ridge sewer system, and thus represent a potential pathway for radiological materials to the city sewage and sludge.

Facility Y-9959 Storage facility received one category score of 4, and a total score of 6. Exterior peeling paint is contributing to environmental contamination. There is minimal chance it will be corrected.

Facility Y-9736 Office building received one category score of 4, and a total score of nine. The exterior paint is no longer in a stable matrix and is contributing to environmental contamination. There is minimal chance it will be corrected.

Facility Y-9959-2 Storage facility received one category score of 4, and a total score of 6. The exterior paint is no longer in a stable matrix and is being spread to the environment.

At **ETTP** ten facilities had at least one category score of four or five: K-1037-C, K-1004-B, K-1004-A, K-633, K-1015, K-1200-S, K-1004-E, K-1004-J, K-1220-N, and K-1401L3.

Facility K-1037-C (Nickel Smelter House) received five category scores of 5, one category score of 4, and a total of 29. This is an old facility in general disrepair. It has numerous roof leaks and is heavily contaminated, both radiologically and chemically. Large scrubber-type vessels located on the East End of the second floor of the barrier production area contain internal radioactive contamination. Discarded contaminated equipment is stored in the building. The facility is posted as a PCB hazard. No corrective actions have been completed at this facility.

Facility K-1004-B (Analytical Chemistry Lab.) received four category scores of 5, and a total of 26. These scores were given for radiological contamination in the ventilation system, and chemical contamination in the drains. No corrective actions have been completed at this facility.

Facility K-1004-A (Analytical Chemistry Lab.) received four category scores of 5, and a total score of 26. These scores were given primarily for chemical contamination in the drain and ventilation systems.

Facility K-633 received five category scores of 5, and two category scores of 4. There is extensive radiological contamination throughout the building, and extensive peeling exterior and interior paint, which contain PCBs, asbestos, and lead. External soil contamination suggests radiological material has moved to the environment.

Facility K-1015 received four category scores of 5 and a total of 27. The facility has a contaminated drain system and has contaminated surrounding soils and the sewer system.

Facility K-1004-E received three category scores of 5 and a total of 21. This facility has a chemically contaminated drain system, and exhibits extensive, peeling exterior lead-based paint.

Facility K-1200-S (Centrifuge Preparation Laboratory, South Bay) received two category scores of 4 and a total score of 26.5. The high score is primarily attributable to the uncertainty of radiological contamination associated with the ventilation system. The interior ductwork and portions of the roof where air is exhausted have not been surveyed for contamination. The potential for airborne release appears great. Equipment inside the facility contains uranium hexafluoride and other hazardous chemicals, and there are numerous radiologically contaminated storage areas. Confined space entry requirements prevented the division from performing a survey of the pits below the centrifuges. The greatest release potential for contaminants would be during decontamination and decommissioning activities. *Equipment removal and cleanup is ongoing at this facility. It is expected that the facility will in the future be removed from the division's "high rankers" list.*

Facility K-1004-J received two category scores of 5, one category score of 4, and a total of 19. This facility was constructed in 1948 and was originally used for uranium recovery from spent fuel solutions and centrifuge research. It originally included a hot cell, reinforced concrete vaults, and a 750 gal. "hot" tank, a 5,500 gal. underground Low Level Liquid Waste tank, and a laboratory. The facility was ranked high in the PER database because of the poor state of knowledge concerning facility infrastructure. First, there is considerable uncertainty over the location and number of active storage vaults under the facility. It is also unknown whether any of these vaults contain radioactive materials or contamination. There is also considerable uncertainty over drainpipe connections and their contribution of radiological and chemical contaminants to general area contamination. No corrective actions have been completed at this facility.

Facility K-1220-N (Centrifuge Plant Demonstration Facility, North) received one category score of 4 and a total score of 18. The interior ductwork has not been surveyed for radiological contamination and the score reflects a high degree of uncertainty concerning the presence of radionuclides. Uranium residuals are present inside the centrifuge systems. After the centrifuge systems are removed and the criticality and security concerns are addressed, this facility is a candidate for reuse. No corrective actions have been conducted at this facility.

Facility K-1401L3 received one category score of 4, and a total score of 15. This ranking was given because of extensive radiological contamination that encompasses the building and housed equipment. There are also suspect contaminated areas that have not been surveyed, such as the areas above 8 feet.

At **ORNL** twenty one facilities had at least one category score of four or five: X-3028, X-3019-B, X-3001, X-7700, X-7700C, X-7701, X-7706, X-7707, X-7720, X-7700B, X-2545, X-3504, X-2531, X-3592, X-3002, X-3020, X-3108, X-3091, X-3085, X-7602, and X-7055.

Facility X-3028 received two category scores of five, five category scores of 4, and a total score of 36. The primary issue with this facility was the relatively large source term of radiological contamination distributed throughout the building. It also shows extensive peeling and chipping of interior wall paint that is supposed to serve as containment for plutonium contamination. Ongoing corrective actions are occurring at this facility.

Facility X-3019-B (High Level Radiation Analytical Laboratory) at ORNL has four category scores of 4, one category score of 5, and a total score of 33. The primary concern with this facility is the very high levels of radiological contamination. The eight hot cells in this facility are "Very High Radiation Areas" and contain many different radionuclides from past operations. The in-cell steam pipes, the off-gas ventilation system, and the ventilation ductwork on the roof are also radiologically contaminated. Also, the Laboratory Off-Gas ductwork located above the hot cells contains perchlorates six times above the maximum recommended by the ORNL Perchloric Acid Committee Corrective. Perchlorates are shock sensitive and have the potential to react violently when disturbed. Signage identifying this hazard is posted, and the situation was recently upgraded from an "Off-normal" to an "Unusual Occurrence."

Facility X-3001 (Graphite Reactor) at ORNL has two category scores of 4, and a total score of 28. The primary concern with this facility is that there is considerable radiological contamination. The air exhaust shaft that vented the reactor pile is contaminated with cesium-137, strontium-90, and fission products. This is a source releasable to the outside environment if a fire or other event occurred in the ventilation system. Several corrective actions, such as the plugging of drains that went to the sewer system, were recently implemented at this facility.

Facilities X-7700, 7700C, 7701, 7706, 7707, 7720, 7700B (Towers, scrapyard, above-ground storage areas, waste storage tank, reactor pool, heat exchanger bldg., battery house, civil defense bunker, below-ground outside source storage area) are all part of the Tower Shielding Complex. A survey of this group of facilities resulted in two category scores of 5, and 14 category scores of 4. The primary issues at this complex of facilities are: soil contamination, uncovered activated and contaminated equipment and material, and drain lines that have direct connections to the environment. Ongoing corrective actions are being carried out at this facility.

Facility X-2545 (Coal Yard Runoff Collection Basins) at ORNL has one category score of 5, two category scores of 4, and a total score of 21. Orphaned, 2- and 6-inch diameter, cast iron Low Level Liquid Waste (LLLW) lines run through the facility property, and a LLLW line box is posted as a radiation area. The area has been chained off and is overgrown with vegetation. Due to the radiological postings, the cast iron LLLW lines are assumed to be degraded and leaking to the environment. ORNL Environmental Restoration staff has been notified of these lines and their condition, but TDEC has not received written confirmation concerning corrective actions.

Facility X-3504 (Geosciences Lab.) received one category score of 5, one score of 4, and a total of 20. The entire building is a posted contamination area. There is also underground and soil contamination outside of the building.

Facility X-2531 (Radiological Waste Evaporator Facility) received one category score of 5, one score of 4, and a total 21. This ranking includes #2537 (Evaporator Pit) and #2568 (HEPA filter bldg.). Even though this is a relatively clean, modern facility, it earned these scores because of several areas of transferable radiological contamination, and high radiological dose rates surrounding the evaporator pit.

Facility X-3592 (Coal Conversion Facility) received two category scores of 4, and a total of 27. Its original mission was to explore the potential for utilizing liquefied coal as an alternative fuel source. But in later years the facility performed lithium isotope separation using massive quantities of mercury. The scores were given for transferable radiological contamination and mercury contamination in the drains.

Facility X-3002 (HEPA Filter House for the Graphite Reactor) has one category score of 4, and a total score of 18. The primary hazards associated with this building are related to the high level of airborne and other radiological contamination in the roughing filter room, the HEPA filter bank, and the ventilation system. Several corrective actions that were recommended by the division were implemented at this facility.

Facility X-3020 (Radiological stack for bldg. 3019A-B) received three category scores of 5, and a total score of 18. All of the major concerns noted for this facility were related to legacy features that are not part of the present-day operational infrastructure. There is an antiquated, contaminated drain line that was part of the ORNL LLLW system. This line leaked and contributed to surface and subsurface contamination of the general area from the 1940's through the 1970's. It was capped in the late 1970's, but is possibly still contributing contamination. There is also a contaminated, above-grade, single-walled concrete sump box attached to the floor drain system.

Facilities X-3108 and 3091 (HEPA filter houses for buildings 3019A-B and Radiological Stack 3020) each received three category scores of 5. #3108 received a total score of 23, and #3091 received a total score of 25. These two facilities are physically connected to the #3020 stack. And like the 3020 Stack situation described above, all major concerns noted with these facilities are related to their non-operational infrastructure. Associated with both facilities is a contaminated drain system that went to the LLLW system. This line leaked and contributed to general-area surface and subsurface contamination from the 1940's through the 1970's. It was capped in the late 1970's, but is possibly still contributing to contamination. Both facilities also contain significant levels of radiological contamination, considerable contaminated aboveground ductwork, and contaminated lower-level HEPA filter pits. Both facilities are non-state-of-the-art structures that are adequately maintained.

Facility X-3085 (Oak Ridge Research Reactor Pumphouse) received one category score of 4, and a total score of 25. This score was based on the possibility for underground leakage of contaminated water from the 10,000-gallon decay tank, and from the underground valve sump tank located in the front of the building. Two empty but internally contaminated, aboveground tanks are still tied to underground piping adjacent to the building. Several recommended corrective actions, such as the plugging of floor drains, have been completed at this facility.

Facility X-7602 (Integrated Process Development Lab.) received one category score of 4, and a total score of 17. The primary concern with this building was the extensive transferable radiological contamination throughout the facility.

Facility X-7055 (Storage Bldg.) scored one category score of 4, and a total score of 7. The only concern with this building was that it has a floor drain system that is connected directly to the outside yard. Even though the building has changed missions and several corrective actions have been implemented, it still contains hazardous materials.

Conclusion

The historic release of chemical and radiological materials from buildings and other facilities on the Department of Energy's Oak Ridge Reservation has led to elevated levels of contaminants in regional terrestrial and aquatic ecosystems. In an effort to understand more about the sources of these contaminants, the division investigates the historic and present-day potential for release of contaminants from facilities through its Facility Survey Program. During its eleven-year history the program has examined 171 facilities and found that thirty five percent (61) pose a relatively high potential for release of some contaminant to the environment. In many cases legacy contamination from degraded facility infrastructure, such as underground waste lines, or substandard sumps and tanks, or ventilation ductwork, will drive high scores until antiquated facilities are fully remediated. This is particularly the case at Oak Ridge National Laboratory where many facilities were connected to an aging low-level liquid waste line system. Inactive facilities that are no longer receiving adequate exterior or interior maintenance are also driving high scores. On many buildings, peeling lead-based paint is extensive, and will only get worse as time passes, if not remediated. Accelerated infrastructure reduction programs that began at Y-12 and ORNL in 2002, and at ETTP in 2003 will help alleviate many of these problem areas.

When facility concerns are noted by the division they are relayed to the Department of Energy via the Facility Survey Report so that corrective actions can be formulated. To date, many corrective actions have occurred, and ten facilities have been removed from the division's list of high Potential Environmental Release facilities. Those concerns that have not been corrected to the extent that the division has reduced the Potential Environmental Release score to less than a "4" are reflected in this report. The rankings are changed when written documentation is received by the division from DOE. And, since the evaluation of corrective actions is an ongoing, time-consuming process, present scores may in some cases not reflect the most recent completed corrective actions.

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CHAPTER 5 RADIOLOGICAL MONITORING

Follow-up on Environmental Restoration Footprint Reduction Maintenance Actions on the Oak Ridge Reservation

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Abstract
The Oak Ridge Reservation (ORR) was placed on the National Priorities List (NPL) in 1989. The purpose of Footprint Reduction was to identify portions of the ORR that have not been environmentally impacted by past federal (Department of Energy – DOE) activities. The mission was to determine which land parcels could be conditionally released from Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements. CERCLA 120-(h) was used as the guideline by the footprint team for the footprint investigations.

The goal was further identified as reducing the size and configuration of the area of the ORR designated as part of the NPL site and determining a No Further Investigation (NFI) status. The land parcels were assigned numerical identifiers ranging from 1 through 20.

Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) performed a radiological walkover and reconnaissance survey of each parcel and adjacent land. The investigation focused on identifying potential anthropogenic sources of contamination and exit pathway releases on the ORR, which could render the parcel(s) unfit for release. In summation, the division investigated 21,439 acres of ORR land during the footprint project.

In performance of the field investigation work, certain maintenance action items were identified on the various land parcels, i.e., "study areas" (see Appendix 1). The division clearly emphasized these concerns to DOE in each footprint study area report released to the public. This current project revisited these sites to determine if action had in fact been taken by DOE to rectify the problems and other division concerns.

Introduction and Scope
The ORR was placed on the National Priorities List (NPL) in December 1989, as a high priority hazardous waste site requiring remediation. In 1992, the Department of Energy (DOE), the U. S. Environmental Protection Agency and the division negotiated the Federal Facility Agreement (FFA) for environmental restoration activities on the ORR. DOE is responsible for cleaning up the ORR following the CERCLA process, which assesses the impacts of ORR areas on human health and the environment. To fulfill this requirement, potential contamination information was collected and reviewed to determine whether CERCLA response activities were needed followed by in the field investigation of ORR areas.

A proposal was submitted to the division in March 1996 outlining a process designed to identify portions of the ORR that have been environmentally affected by past federal activities. The DOE Environmental Restoration Footprint Reduction process was designed to investigate and assess those areas of the ORR likely to have been environmentally affected by past federal activities. In addition, determinations were made as to which land parcels could be conditionally released from CERCLA requirements and removed from NPL status. The focal regulatory requirement for the project was the CERCLA 120-(h) investigative process, which is used to identify the presence or likely presence of hazardous substances on property being transferred by federal agencies. The CERCLA 120-(h) investigative process uses the following information sources to identify the presence of hazardous substance contamination on federal land: historical land use information, aerial photography, remote sensing data including gamma aerial reconnaissance photos, and field investigation/verification.

The division performed a radiological walkover and reconnaissance survey of each parcel and adjacent land. The investigation focused on identifying potential anthropogenic sources of contamination and resulting release pathways on the ORR, which might render the parcel(s) unfit for release. The contamination could be in the form of solid waste, radiological waste, hazardous waste, or in surface water. Groundwater contamination will be addressed in detail if the property is released to the public.

Areas or facilities found to be contaminated within the various study areas during the parcel evaluation were added to Appendix C of the Federal Facilities Agreement (FFA) as CERCLA maintenance action sites. Uncontaminated study areas or portions of study were recommended for No Further Investigation status under the Footprint Reduction program.

The goal of the program was to reduce the size and configuration of the "footprint" area acerage of the ORR ("behind the fence") designated as part of the NPL site. Essentially, the effort was designed to distinguish "greenfield" from "brownfield" areas behind DOE institutional control boundaries.

During the execution of the fieldwork on each footprint study area, certain maintenance action items were determined in need of removal. Additional areas were found where abandoned field gear and trash from research projects needs clearing or removal. Each footprint parcel was investigated and a final report on the respective study area was generated and issued by the footprint team. The division clearly identified maintenance action problem areas to be addressed by DOE in each of the applicable 20 footprint study area reports (not all parcels had cleanup problems). During calendar year 2003, the division "follow-up footprint project" revisited all the previously determined maintenance action sites to determine compliance with the requested maintenance actions. Official site visits were not performed as a routine manner for calendar year 2004. Instead spot checks were made during work on other projects.

In addition, the division has added the parcel ED-1 Mitigation Action Plan (MAP) requirements into this project as well. Required environmental monitoring by DOE and CROET per the MAP has become a concern. The division will follow up on this project with field excursions in addition to requesting DOE to honor its responsibilities per the MAP document.

Methods and Materials

The purpose of Footprint Reduction was to identify portions of the ORR potentially impacted by past federal activities. The division performed a radiological walkover and reconnaissance survey of twenty parcels and adjoining land. The field investigation focused on possible anthropogenic sources of contamination that might render each parcel unfit for release. The parcels were investigated and walked over by division staff using field radiological detection instruments (i.e., Ludlum model 2221 scaler-ratemeter with a 2 x 2 inch sodium iodide crystal). Portable gamma spectrometer equipment was used to identify isotopes present at sites where above background detections of radiation were discovered. The division also used a micro-rem meter that provides data in tissue dose equivalent units (rem). Global positioning system (GPS) technology was employed to locate field survey points and to confirm the location of anomalous features.

Historical land use investigations, aerial photography analysis, and remote sensing data were studied for evidence of federal activities that could have potentially resulted in adverse impacts to the environment. Magnetic and radiologic anomalies were plotted on maps prepared by DOE contractor Lockheed Martin Energy Research (LMER) Geographic Information Science and Technology (GIST) staff for field investigation applications. The division reviewed the map and other data furnished by LMER GIST staff, as well as all pertinent information and data from division files. The sheer size of the area to survey, and topography of the land parcels precluded the use of grid survey techniques. After a detailed study of survey techniques and requirements, it was determined that the survey effort would concentrate on mapped locations of magnetic and gamma fly-over anomalies. Aerial photography was investigated and studied thoroughly to evaluate potential land use changes over time.

The division investigated the anomalies identified on the anomalies maps plus suspicious sites observed on historical aerial photos. Cultural changes, non-sequential vegetation changes, radiological anomalies, and geophysical anomalies were investigated. Karst features, springs, abandoned and existing roads, and other unusual sites were inspected when found in the field. Threatened and endangered plant species and Native American sites were on the list of potentially important sites to be considered for exclusion and protective status.

The physically demanding and time-consuming task of walking over the parcels provided the best method of coverage and obtaining the best quality and most reliable information. Routes were selected that would ensure maximum coverage of the parcels. Abandoned roads and trails were walked to determine if hazardous materials or wastes had been dumped on site. Magnetic anomalies were examined to ensure that there were no observable metals, wastes or structures present. Remote areas were investigated to determine if evidence of past federal activities were present. Division staff concluded fieldwork on all of the 20 parcels in early 2000 (totaling approximately 24,754 acres - see Figure 2).

Results and Discussion

Division field teams located the pre-mapped anomalies in the field utilizing GPS technology. Measurements of ambient gamma radiation were taken at each anomalous site or survey site to determine if any contamination from DOE operations (or its federal predecessors) could be detected. Other points were selected and investigated on a random or functional as-needed basis.

Historical investigations, aerial photography analysis, and remote sensing data were studied for evidence of federal activities that could have potentially resulted in adverse impacts to the environment. Magnetic, historical, and radiological anomalies were plotted on maps to assist the field investigation team.

During the course of the five (5) plus year Footprint Reduction project, several maintenance action sites in need of remediation were identified. In addition, several new solid waste management units (SWMUs) were discovered and recommended for exclusion from the parcels (see Figure 1 for locations of all sites). All these sites were to be addressed by DOE at a later date (see Appendix 1 for the maintenance action list). The SWMU sites were given priority by DOE and it's subcontractors for appropriate maintenance action. Identification numbers and names were assigned to the sites, and each SWMU was cordoned off with yellow and magenta rope (if radiologically contaminated), placarded, or otherwise flagged, and was added to the FFA Appendix C list. There was one small barn structure at ETTP that was found to have fixed contamination (radiological) on its floor. This facility was immediately provided with appropriate institutional controls as a radiological area.

The intent of this current "follow-up" project was to revisit those areas of concern and determine the status of the requested maintenance actions. All sites were compared to the Appendix C of the FFA to ensure inclusion. Unfortunately, due to budgetary cut-backs or prioritization changes on DOE's part, none of the maintenance action sites except for the SWMUs have received the requested attention or response.

<u>Conclusions</u>

During 2003, division staff returned to the location of the 44 sites listed in Appendix 1 to investigate and determine if division requested maintenance actions had been carried out by DOE, which would alleviate the problems. Essentially, no action has been taken to address the sites of concern. The cursory visits made to several of the sites in 2004 showed no evidence to refute previous findings. Therefore, concerns by the division continue to be justified for (public) human health and the environment due to DOE's lack of response. The important aspect for this project is to make sure these small areas, although not high priority, do not slip through the layers of remediation. DOE appropriately addressed the new SWMU sites discovered by the division. Each SWMU was cordoned off with yellow and magenta rope (if radiologically contaminated), placarded, or otherwise flagged, and was added to the FFA Appendix C list.

Division staff will continue to vigorously follow up on the areas of concern until the desired response by DOE is achieved, thereby providing resolution of concerns by the division. The possibility that groundwater contamination will migrate from impacted areas of the ORR into the study areas exists and constitutes the need for groundwater use restrictions.

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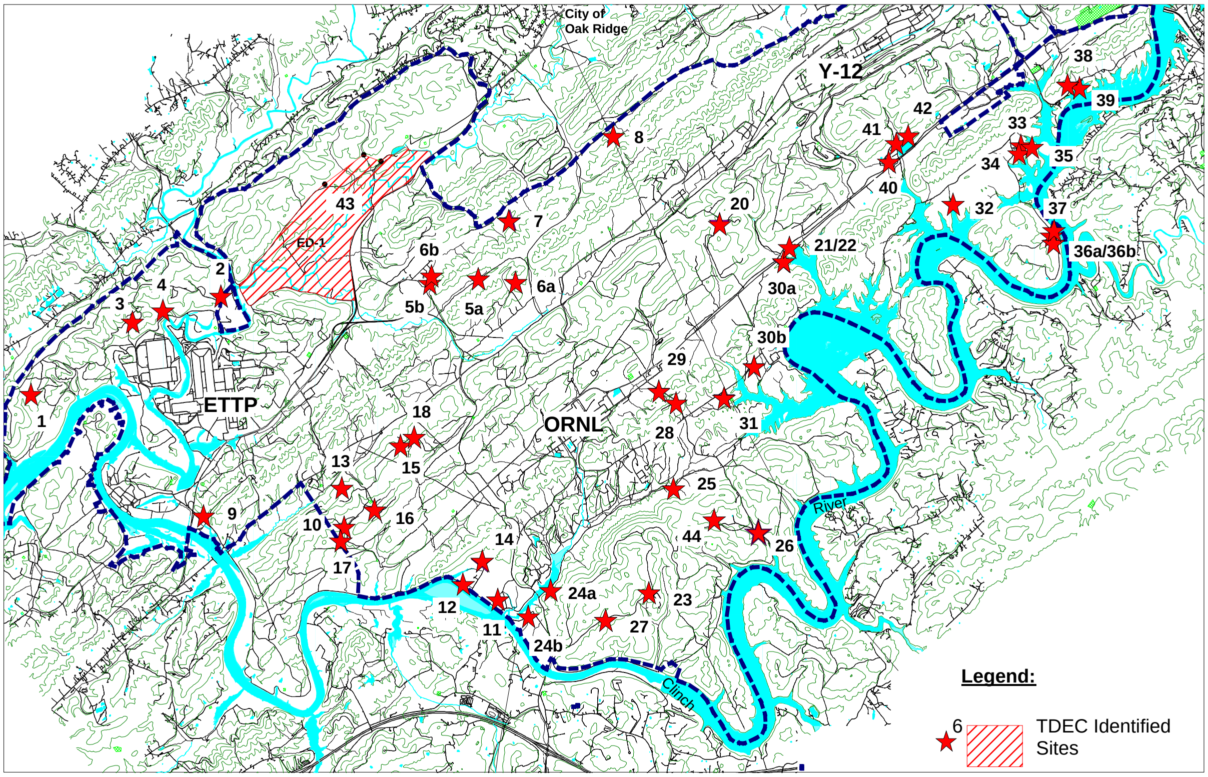

FIGURE 1: Footprint Reduction – Maintenance Action Sites

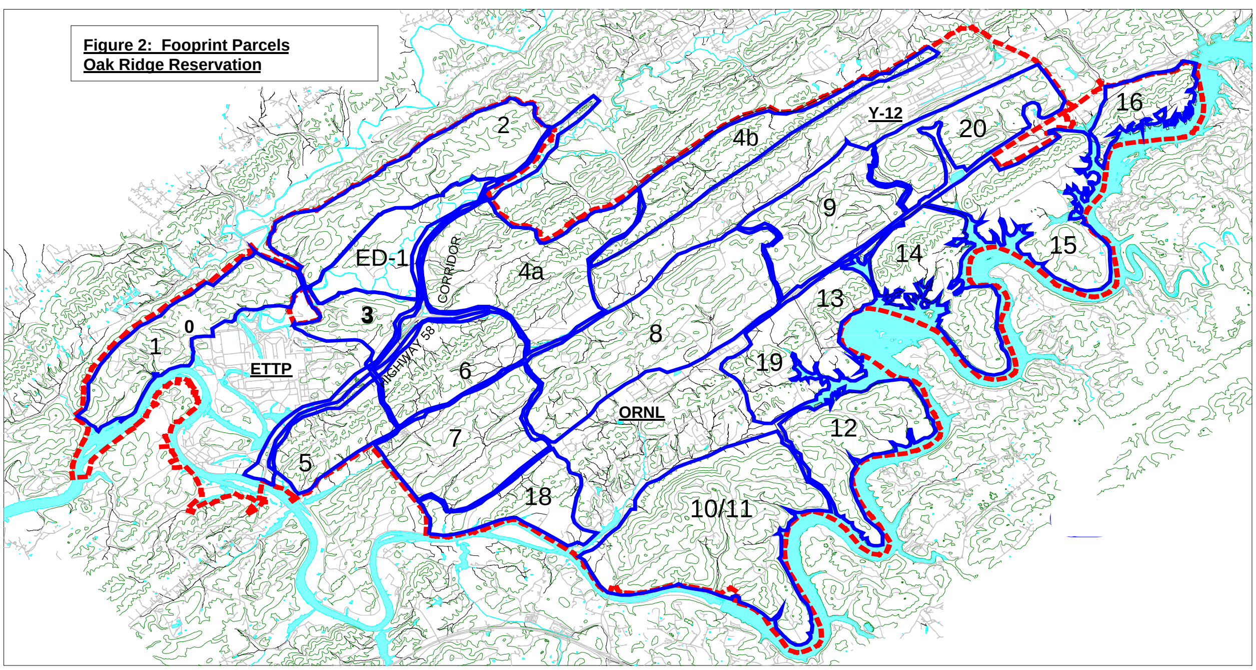

FIGURE 2: Footprint Parcels – Oak Ridge Reservation

APPENDIX 1

LIST OF MAINTENANCE ACTION SITES IDENTIFIED BY TDEC FIELD SURVEYS (FOOTPRINT REDUCTION PROCESS)

Map Reference	Maintenance Action Concern and Site Description
	Parcel 1: West Black Oak Ridge Study Area
1	TDEC field station 101: Abandoned 55-gallon steel drum (empty)
2	TDEC field station 127: Old dumpsite (tires, roofing, scrap metal, etc.)
3	TDEC field station 129: Small shed with above background levels of fixed gamma contamination
4	TDEC field station 134: Large abandoned hollow fill
	Parcel 2: East Black Oak Ridge Study Area
	None specified
	Parcel 3: McKinney Ridge Study Area
	None specified
	Parcel 4a: East Fork Ridge/White Wing Study Area
5a/5b	TDEC field stations 24 & 125: Abandoned 55-gallon drums
6a/6b	TDEC field stations 105-124: Numerous abandoned hydrologic experimental equipment
7	TDEC field station 157: Remains of plywood shack and drums
	Parcel 4b: Pine Ridge Study Area
8	TDEC field station 89: Abandoned barrel with residual fuel oil
	Parcels 5/6: West Pine Ridge Study Area
9	TDEC field station 44: Old Dump Site at west end of Happy Valley Campsite
	[Radiological surveys should be conducted prior to use of federal land adjacent to the Consolidated Clinch River Industrial Park to ensure potential exposure is minimized]
	Parcels 7/18: West Chestnut Ridge/West Bethel Valley Study Area
10	TDEC field station 14: Abandoned 55-gallon drum
11	TDEC field station 26: Pile of scrap metal
12	TDEC field station 35: Abandoned automatic sampling equipment along small creek
13	TDEC field station 49: Experimental hydrologic site with abandoned equipment & test gear
14	TDEC field station 89: Abandoned hydrologic/precipitation experimental equipment
15	TDEC field station 103: Abandoned soil percolation test trenches and test gear
16	TDEC field station 105: Abandoned hydrologic experimental gear strewn about the hillside
17	TDEC field station 114: Abandoned experimental site and test gear
18	TDEC field station 193: Abandoned percolation test trench and equipment

Map Reference	Maintenance Action Concern and Site Description
19a/19b	TDEC field stations 250/251: Abandoned hydrologic test site with copious amounts of abandoned equipment
	Parcel 8: Central Chestnut Ridge Study Area
20	TDEC field station 15: Debris & scrap metal strewn about the NOAA/ATDD facility
21	TDEC field station 168: SWMU 0.81 site including broken asphalt, concrete, scrap metal, & local dumping of trash; [same location as map reference 22]
	Parcel 9: Walker Branch Study Area
22	TDEC field station 77: Removal action requested for miscellaneous trash and debris associated with SWMU 0.81 located between Old and New Bethel Valley Roads [same location as map reference 21]
	[Removal action is recommended for abandoned experimental gear, scrap metal, hydrologic test equipment and trash strewn about the entire parcel]
	Parcel 11: Copper Ridge Study Area
23	TDEC field station 27: General vicinity of the Civil Defense Bunker needs trash picked up
24a/24b	TDEC field stations 119 & 297: Abandoned drums
25	TDEC field station 133: Gamma-contaminated site along old roadbed on ridge overlooking HFIR to the north
26	TDEC field station 250: Abandoned & unidentified waste dump (scrap metal, blocks, bricks, etc.)
27	TDEC field station 313: Tire dump
44	"Cesium Forest"
	Parcel 12: Park City Road Study Area
	None specified
	Parcel 13/19: West Haw Ridge/Bearden Creek Watershed Study Area
28	TDEC field station 12: Previously unidentified SWMU contaminated with Cs-137
29	TDEC field station 21: Small dump site adjacent to Melton Valley Access Road which is slightly rad-contaminated
30a/30b	TDEC field stations 50 & 139: Abandoned empty 55-gallon drums
31	TDEC field station 89: Previously SWMU dump (lab equipment, scrap metal, etc)
	Parcel 14: Gallaher Bend/Bull Bluff Study Area
	None specified
	Parcel 15: Freels Bend Study Area
32	TDEC field station 6: Abandoned 55-gallon drum partially submerged in a cove along the shoreline of Melton Lake
33	TDEC field station 20: VDRIF facility needs to have shielding blocks removed from the roof of the structure
34	TDEC field station 21: Demolition debris needs cleared and removed
35	TDEC field station 23: Location of small subterranean vault which held lead source rods; reportedly sand filled

Map Reference	Maintenance Action Concern and Site Description
36a/36b	TDEC field stations 35 & 36: Existing barns need to be cleared of trash & veterinary IV needles/medicine bottles
37	TDEC field station 52: Trash and debris disposed in large sinkhole (standing water)
	Parcel 16: Scarboro/East Haw Ridge Study Area
38	TDEC field station 6: Anomaly 12 at contaminated trailer
39	TDEC field station 7: Building 1404-7 at the location of a radiologically-contaminated hopper
	Parcel 20: East Chestnut Ridge Study Area
40	TDEC field station 36: Abandoned scrap pile/refuse along the Brush Burn Access Road
41	TDEC field station 38: Abandoned scrap metal/asbestos pile located north of Rogers Quarry
42	TDEC field station 39: Abandoned scrap metal pile located north of the Rogers Quarry highwall
43	Parcel “ED-1”

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CHAPTER 5 RADIOLOGICAL MONITORING

Pilot Project for Radon Monitoring (RMO)

Principal Authors: Howard Crabtree, Natalie Pheasant

Abstract

In 2001, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Division began a pilot study designed to assess the feasibility of monitoring radon at burial grounds on DOE's Oak Ridge Reservation. The project was prompted by a concern that the disposal of large amounts of uranium in reservation burial grounds could result in elevated radon levels (radon is produced by the natural decay of radionuclides in the uranium decay series). While the parent radionuclide of radon, radium, should be largely removed during uranium ore processing, concentrations of radium, radon, and other radionuclides in the decay series can be expected to increase over time as the tons of uranium disposed on the reservations decay. The results of the study indicated that radon levels can be measured using the technique developed for the project and concentrations of radon were higher (above background levels) over localized areas within the burial grounds.

Introduction

In 2001, the Tennessee Department of Environment and Conservation Department of Energy Oversight Division began sampling radon levels over the Bear Creek Burial Ground near the Y-12 National Security Complex. This sampling is part of a pilot study designed to assess the feasibility of monitoring radon levels at waste disposal areas on the ORR. Radon is a natural constituent of rocks and soil throughout the United States. A colorless, odorless, radioactive gas, radon is formed by the normal decay of radionuclides in the uranium decay chain. As radon, itself, decays, its daughter radionuclides polonium-218, polonium-214, bismuth-214, and lead-214 are produced. Most of the damage attributed to radon is actually caused by the short-lived daughters. These radionuclides tend to attach to air-borne particles that can lodge in the lungs when inhaled, causing damage to cells lining the airways and potentially resulting in cancer. Radon and its daughter radionuclides are believed to be the second leading causes of lung cancer in the United States today (the first is smoking cigarettes).

Since the beginnings of the Manhattan project, more than 40,000,000 pounds of uranium has been disposed on the Oak Ridge Reservation (ORR). While most of this uranium should have been stripped of decay products during the milling and refinement process, concentrations of these radionuclides increase as the uranium decays. As a result, the risk associated with the disposed uranium can be expected to increase over time. While the generation of radon is slowed by the long half-lives of some of the intermediary radionuclides in the decay chain, the quantity of uranium that has been disposed resulted in a concern that radon emissions could present a hazard on the ORR; an issue particularly relevant when assessing the consequences of leaving thousands of tons of uranium buried on the ORR for perpetuity.

Methods and Materials

To measure the radon concentrations, the project used Radtrak® Radon Gas Detectors, which were housed in five gallon plastic buckets. Ventilation was provided by holes one-half inch in diameter approximately one-inch above the bottom of each of the containers. The detectors were affixed to the inside bottom surface of the containers, which were placed at the sampling locations, inverted, then secured with tent stakes (Figure 1).

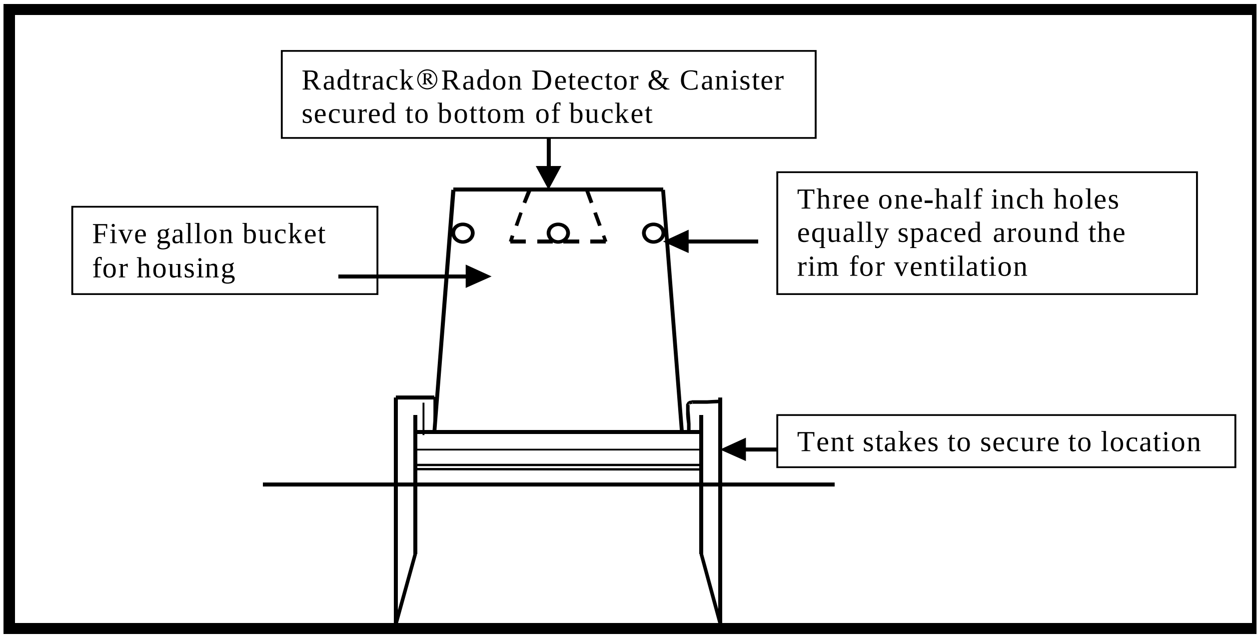

Figure 1: Configuration of Radon Detector Housing (*not to scale*).

In the summer and fall of 2001 (05/15/01-10/20/01), spring of 2003 (02/04/03-06/04/03), and winter of 2003/2004 (12/16/03-05/13/04), the radon detectors were placed over uncapped portions of the Bear Creek Burial Grounds (Figure 2) and at background locations in the same geologic formation. After four to five months in the field, the detectors were collected and shipped to the vendor for processing. Upon their receipt, the results were reviewed for consistency and the data from the burial grounds compared to the results for the background measurements.

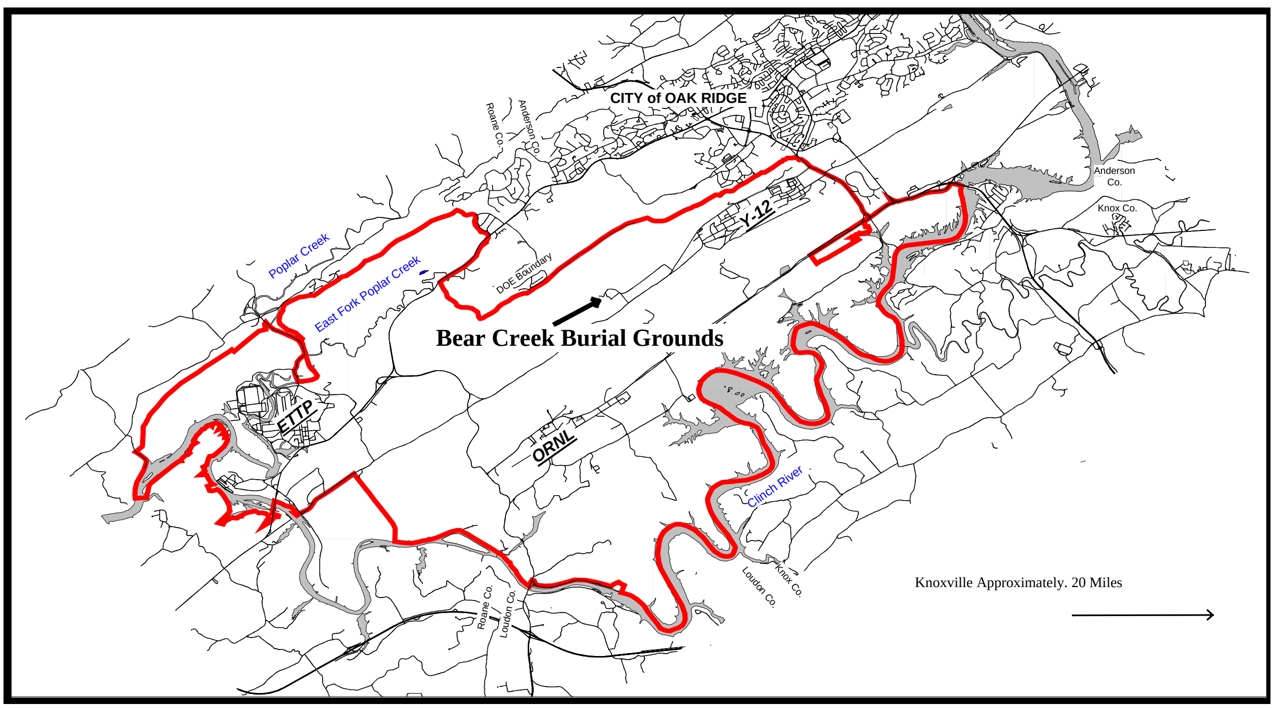

Figure 2: Bear Creek Burial Grounds

It should be understood, the sampling methodology used in this program was designed to capture radon emissions released from soils beneath the five-gallon containers. The measurements are not representative of ambient air concentrations, which should be much less, because of natural dispersion mechanisms (e.g., wind) and the dilution provided by the ambient environment.

Results and Discussion

In general, ambient radiation levels follow seasonal trends due to the influence of natural phenomena that control the concentrations of radiation in the environment. In regard to radon, wind movement, precipitation, barometric pressure, and temperature each play a role in these variations and relatively large seasonal fluctuations are considered normal.

The above effect can be noted in Figure 3 by comparing the results for samples collected in the spring and winter with those collected in the summer. The largest results were reported in the summer, when radon levels are expected to be at their highest. As can be noted in Figure 3, the results dropped dramatically in the spring and winter sampling events for both the background and burial ground samples, suggesting the major influence resulting in the decrease could be attributed to natural seasonal variations that control the amount of radon released through the soils into the atmosphere.

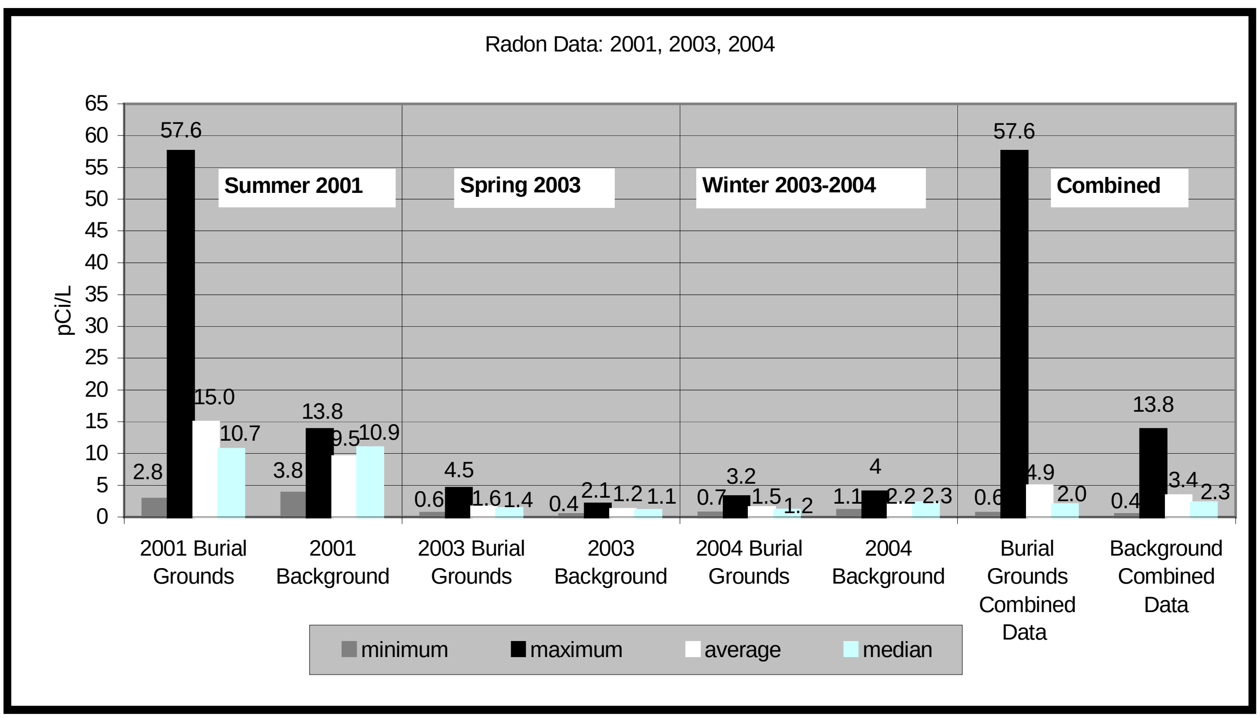

Figure 3: Summary of Results for Radon Samples taken at the Bear Creek Burial Grounds in the Summer 2001, Spring 2003, and Winter of 2004/2004 (pCi/L)

In addition to the seasonal changes, one of the burial grounds being sampled was covered by a layer of soil, seeded, and upgraded to a radiological contamination area after the summer of 2001. The soil cover was emplaced to control the spread of uranium wastes discovered on the ground surface by staff deploying the radon detectors, during the initial sampling effort. The wastes observed are believed to be artifacts of a uranium fire and included uranium oxides condensed on rock surfaces, uranium ash, and machine turnings (Figure 4).

Figure 4: Radioactive Materials observed in the BG-D East Section of the Bear Creek Burial Grounds *(Photos provided by the Department of Energy)*

In general, the data for the burial grounds and the background data were similar in 2001. Two results from the burial ground (57.6 and 32.2 pCi/L) were considerably higher than the other samples, skewing the average concentration for the burial grounds higher than for the background samples. However, the median values remained close (10.7 vs. 10.0 pCi/L): suggesting conditions at the two sites were similar, aside from the exceptions noted. This pattern was repeated in the results from the spring of 2003, but at much lower levels. The results for the samples taken at the burial grounds in the winter of 2003/2004 were similar to the data reported the previous spring, but the data for the background locations rose slightly. It is believed, the soil cap emplaced over the burial ground may have restricted radon movement reducing the amount of radon emanating from the burial ground and resulting in the anomalous data.

Conclusion

Overall, the combined results obtained from the project indicate: (1) the concentrations of radon above the burial grounds can be measured, using the techniques developed for the project; (2) seasonal variations can be dramatic, (3) localized areas within the burial grounds exhibited higher radon levels than measured at the background locations; (4) median values for the background locations and the burial grounds were relatively close, and (5) the average concentration for the results from the burial ground measurements tended to be skewed high by one or two results much larger than reported for the other sampling locations.

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CHAPTER 5 RADIOLOGICAL MONITORING

Surplus Material Verification

Principle Author: John McCall

Abstract

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division's (the division) Radiological Monitoring and Oversight Program conducted random radiological monitoring of surplus material offered for sale to the public. A total of 21 inspection visits were conducted at the Oak Ridge Reservation (ORR) facilities. No sales were conducted at the ETTP facility. No radiological contamination was discovered during the radiological monitoring. Four items were observed that required further evaluation.

Introduction

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division), in cooperation with the U.S. Department of Energy and its contractors, conducts random radiological surveys of surplus materials that are destined for sale to the public on the Oak Ridge Reservation (ORR). In addition to performing the surveys, the division reviews the procedures used for release of materials under DOE radiological regulations. Some materials, such as scrap metal, may be sold to the public under annual sales contracts, whereas other materials are staged at various sites around the ORR awaiting public auction/sale. The division as part of its larger radiological monitoring role on the reservation conducts these surveys to help ensure that no potentially contaminated materials reach the public. In the event that radiological activity is detected, the division immediately reports the finding to the responsible supervisory personnel of the surplus sales program and follows their response to the notification to see that appropriate steps (removal of items from sale, resurveys, etc.) are taken to protect the public.

Methods and Materials

Staff members make random surveys of items that are arranged in sales lots by using standard survey instruments. Inspections are scheduled just prior to sales after the material has been staged. Items range from furniture and equipment (shop, laboratory and computer) to vehicles and construction materials. Particular attention is paid to items originating from shops and laboratories. Where "green tags" are attached, radiation clearance information is compared to procedural requirements. If any contamination is detected during the on-site survey, the surplus materials manager for the facility is notified immediately.

Results and Discussion

A total of 21 inspections were conducted at ORNL and Y-12. No sales were held at ETTP. No radiological contamination was discovered during the DOE-O surveys. There were two items observed at the ORNL surplus sales facility that required further evaluation. During an inspection on January 21, 2004, an equipment item was observed that had a radiation sticker and a radiological release tag. Further evaluation by ORNL Radiological Support Services determined that the radiation sticker referred to an internal source that had been removed prior to sending the equipment for sale. The sticker was removed and the equipment was included in the sale. In an inspection on March 23, 2004, a leak detector was examined. An integral part of this type of leak detector is a high vacuum system using vacuum pumps and associated piping. The radiological release tag showed no detectable contamination. However, the tag was not checked in the area that showed that the equipment custodian could certify that the internal parts were contamination free.

A further check with the custodian determined that the history of the equipment was not known enough to certify the internal parts were contamination free so the item was removed from the sale.

Two observations were made at the Y-12 surplus sales facility. In an inspection on November 4, 2004, one lot was listed as being part of an x-ray spectrometer assembly. It was not possible to determine at the time whether or not the equipment still contained an x-ray source. The item was not sold and Y-12 surplus sales personnel were referred to the Tennessee Division of Radiological Health for information on requirements for licensing requirements for transferring equipment with radiological sources. The second observation did not involve radiological material, but resulted in the removal of several safes from a sale. In an inspection on August 22, 2004, several safes were observed that had locks that had been drilled out due to lost combinations. These safes were labeled with possible asbestos stickers and there was loose fibrous material around the drilled holes. Since the material was possibly loose asbestos the safes were removed from the sale and returned to the custodian.

Conclusion

Hundreds of surplus materials items were sold through ORNL or Y-12 surplus sales organizations in 21 separate sales events. The facilities have performed a good job of preventing radiological contamination from reaching the public through their surplus material sales as evidenced by the fact that no radiological contamination was detected in the surveys conducted. There were only two instances of items that were removed from sales and returned to the submitting group.

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CHAPTER 6 SURFACE WATER MONITORING

Bear Creek Uranium Study

Principle Author: John Edward Sebastian: RRPT, PG, GEO III

Abstract
Bear Creek Uranium Study (BCUS) 2004 encountered structural and environmental problems in the seminal process of sample collection in 2004. Sampling efforts for this study were limited during 2004. Only nine locations were sampled of an expected twenty three (23). In 2001 it was observed that uranium in Bear Creek Valley was delivered into Bear Creek and its associated karst and fracture flow groundwater systems along a few discrete high concentration low flow surface and subsurface drainages. After the initial entry of uranium into Bear Creek the contaminant then followed a complex interconnected surface and subsurface pathway. Gross alpha flux data continue to suggest complex surface and subsurface pathways that reflect ambient rainfall conditions, which control fate and transport through the complex fracture and conduit subsurface groundwater as well as surface systems to and through Bear Creek. Data from 2003 suggest that anthropomorphic activities had created a significant increase in the flux of dissolved uranium moving through Bear Creek Valley.

Introduction
During the 2004 calendar year, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Division collected an abbreviated series of radiological samples along Bear Creek, its tributaries, and associated springs for the purpose of determining the transport and fate of uranium disposed in Bear Creek Valley. As uranium is an emitter of alpha radiation, gross alpha measurements were used as indicators of the uranium concentrations in waters of Bear Creek and contributing springs and seeps. The flows in the streams were estimated at the time the samples were taken. This enabled a measurement of flux to be generated by combining the reported concentrations of gross alpha with the flow measurements. Dissolved uranium in the waters of Bear Creek originates in the eastern portions of Bear Creek Valley from the Y-12 Plant and the numerous disposal sites in Bear Creek Valley associated with DOE legacy operations. In particular several million kilograms of depleted uranium has been disposed of by burial in the valley.

This study is based on the assumption that gross alpha can be used as an acceptable substitute for dissolved uranium in Bear Creek. Detailed isotopic analyses were performed during 2001 to support this contention. This provided data that indeed showed that gross alpha concentrations were an acceptable indicator of uranium dissolved in the waters of the Bear Creek hydrologic regime.

Location: Bear Creek Valley is located on the Oak Ridge Reservation (ORR) within East Tennessee’s Valley and Ridge Physiographic Province. Bear Creek drains the western portion of the Department of Energy (DOE) Y-12 Complex. The northeast/southwest trending valley lies between Pine Ridge to the northwest and Chestnut ridge to the southeast, which is common to the long narrow valleys of this physiographic province. Bear Creek, along with its internal complex karst and fracture flow groundwater systems, drains a number of sites used to dispose of depleted uranium from historic DOE processes.

Geology: Fractured clastic and carbonate Cambrian aged sedimentary rocks of the Conasauga Group underlie Bear Creek Valley. Sedimentary beds strike in a general northeastern manner and dip approximately 30 to 45 degrees toward the southeast. Within the regional structure of imbricate thrust blocks (Bear Creek Valley and its bordering ridges form part of one such block), deformation can become too complex for description. The valley is segregated into a number of fractured clastic formations that underlie the majority of the valley's surface and one well developed karst unit, the Maynardville Limestone, which runs parallel to the base of Chestnut Ridge and in some areas forms the lower slopes of Chestnut Ridge. Adjacent to the Maynardville Limestone are the dolomites of the Cambrian and Ordovician aged Knox Group formations. The Knox Group aquifer is also a developed karst dominated by conduit flow groundwaters.

Hydrogeology: Groundwater and surface water movement in the valley is dominated by the well-developed karst of the Maynardville Formation. With the exception of occasional deeper fracture systems within the clastics, much of the meteoric water that falls on the clastic units is carried by surface or near surface runoff into Bear Creek and its underlying karst aquifer. The creek itself is merely the surface expression of the well-developed karst drainage and is composed of a series of gaining and losing stretches. Entire portions of the creek's flow can be observed seasonally (in at least one location) cascading into a swallet formed in the limestone of the creek bed. In this regard, the upper reaches only flow continuously when the underlying karst has been filled to capacity with rainwater. A series of springs, which most likely represent a seasonally variable mixture of waters from the Maynardville karst aquifer and the adjacent Knox Group aquifer exists along the base of Chestnut Ridge and contributes considerable flow to the Bear Creek System.

Methods and Materials

For the purposes of the study, gross alpha concentrations were utilized to represent dissolved phase uranium (an alpha particle emitter) in the waters of the Bear Creek system. In 2001, to verify the usefulness of the assumption that gross alpha was an acceptable substitute for more direct measurements of uranium; alpha spectrographic analysis was performed on a number of samples, in addition to the measurements of gross alpha concentrations. Results showed that in this environment gross alpha is a reasonable indicator of uranium concentrations moving through the Bear Creek system.

Generally, sampling points (Figure 1) can be divided into three groups: springs, tributaries, and Bear Creek itself. However, each of the sampling points in the three groups tends to be related to each other in such a way that a cross section of the watershed was sampled essentially simultaneously.

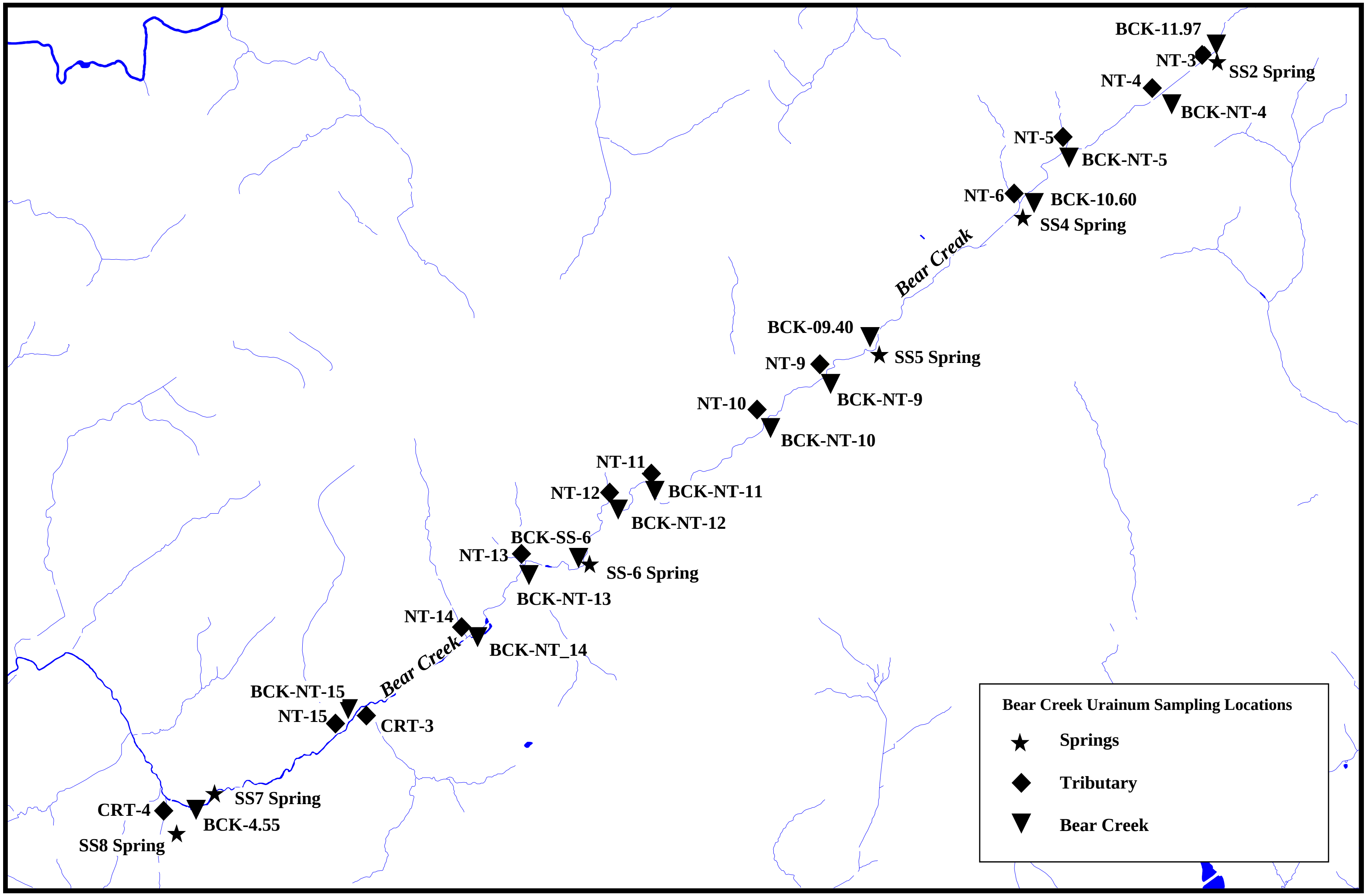

Figure 1: Uranium and Gross Alpha Sampling Points in Bear Creek Valley 2001 to 2004

During the 2004 BCUS samples were collected at springs and in Bear Creek itself. Sampling was not completed per the BCUS work plan because of several reasons. First, the personnel responsible for this study assumed different responsibilities. Second, during sampling of one of the seeps near the EMWMF samplers experienced exposure to elevated VOCs concentration. Therefore, sampling at this site and others was curtailed.

Results and Discussion

In previous years gross alpha concentrations along with flow measurements were used to create fluxes, expressed as pico-curies per second. In 2004 only concentration data is presented. Locations and timing for sampling in Bear Creek and its environs were chosen in such a manner as to provide a determination of both the source and fate of the contaminant mass. In 2004 samples at the tributaries were not collected.

Bear Creek

In 2004 gross alpha activities for the New Weir and Bear Creek Weir (BCK-4.55) were seen to increase slightly from the data collected in 2003. Figures 2 and 3 show Gross Alpha activity at New Weir and BCK 4.55 for 2001 through 2004, respectively.

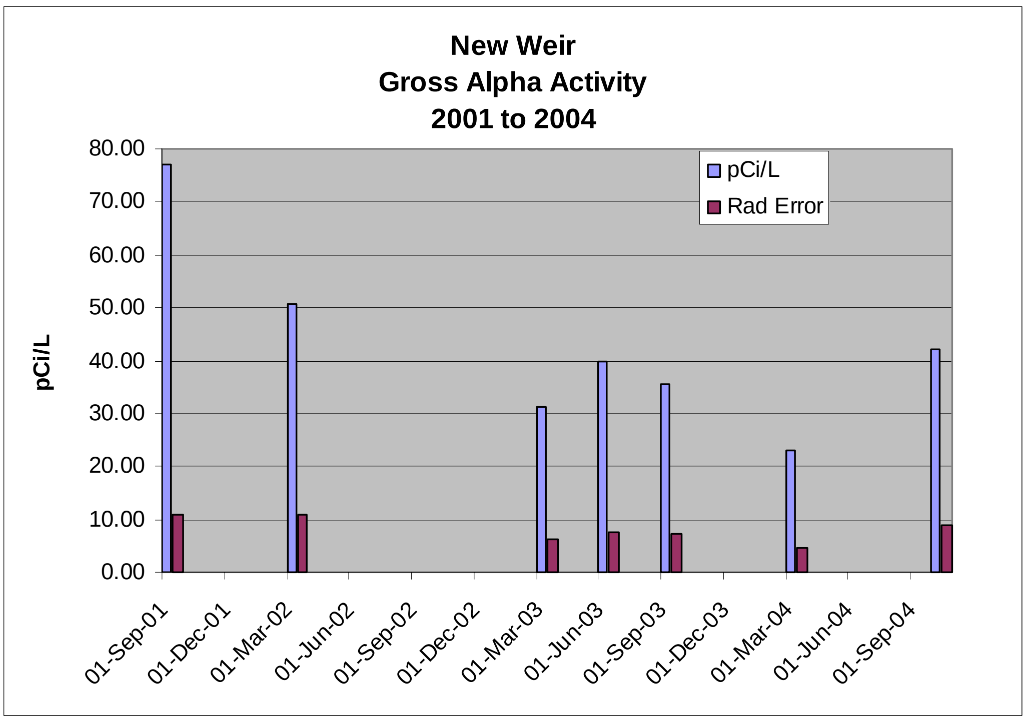

Figure 2, Activity in pCi/L Gross Alpha for New Weir on Bear Creek 2004

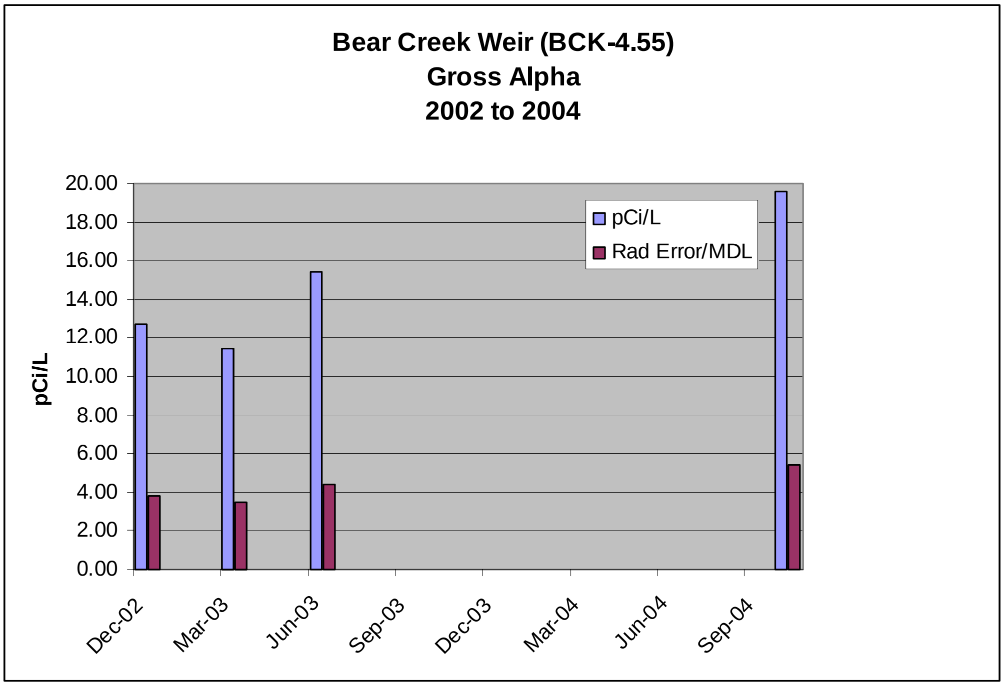

Figure 3 Activity in pCi/L Gross Alpha for Bear Creek Weir (BCK-4.55) on Bear Creek 2004

Results obtained from the middle reaches of Bear Creek (New Weir) tended to suggest that conditions in 2004 remained essentially the same as in 2003.

In general the observed behavior of the activity of gross alpha in the valley during 2003 and 2004 following the remediation of Boneyard Burnyard is not promising. While any and all source removal is in and of itself a good thing it must be observed that any great loss of sediments from the source area may in fact represent the creation of a new source in and of the sediments deposited in and around Bear Creek.

Sedimentation from the upper reaches of Bear Creek was observed to continue during 2004.

Springs

Behavior of gross alpha in springs in Bear Creek Valley can be seen in the following three figures, (four, five and six) the activity of gross alpha contributed by the springs was considerably less than the portion born by Bear Creek’s waters. This is interpreted to indicate that uranium contamination in the springs is in general sourced from losing reaches of Bear Creek, the balance of those spring waters being sourced from uncontaminated water from the Knox Aquifer that underlies Chestnut Ridge. In fact gross alpha activities and corresponding fluxes can be essentially traced from losing reaches of Bear Creek around kilometer 11.97 to the springs down gradient, particularly spring SS-4.

Of interest also is the close and expected mimicking of the behavior of contaminant flux from the springs with that of Bear Creek itself indicating the strongly coupled nature of the surface and groundwater systems above and within the conduit dominated flow regimes of the karst aquifer.

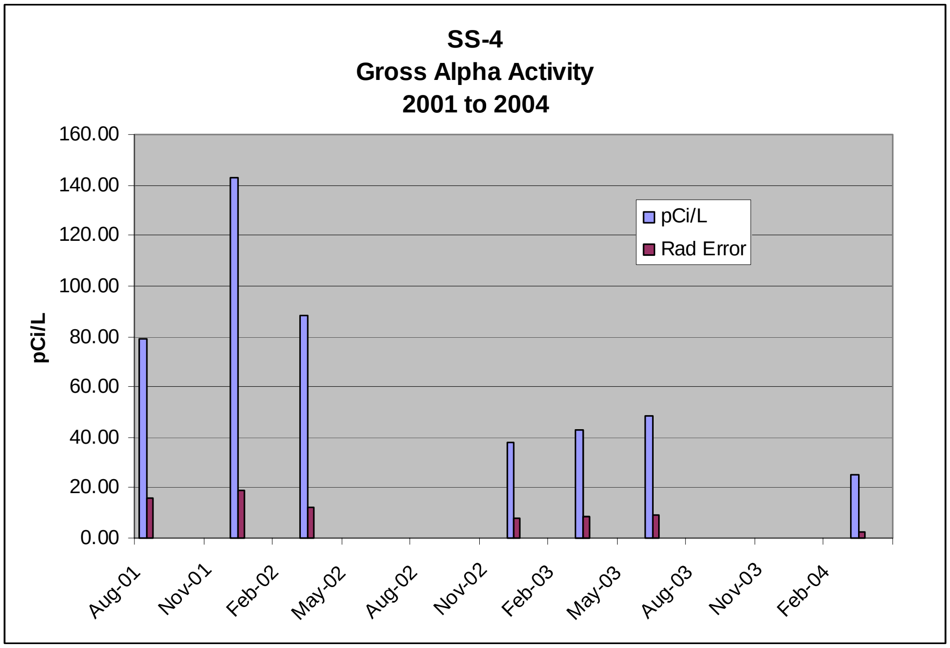

Figure 4, Activity in pCi/L Gross Alpha Spring SS4 on Bear Creek 2004

The charts are arranged for selected springs proceeding from the top of the study area to the lowest portion, other springs were sampled but results tend to closely mimic the springs shown.

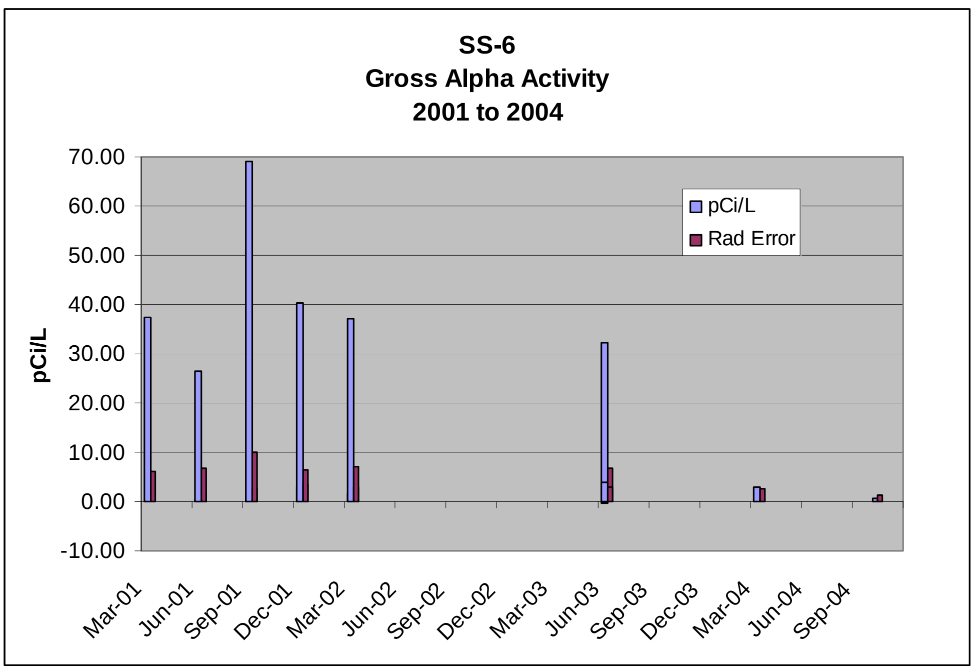

Figure 5, Activity in pCi/L Gross Alpha Spring SS6 on Bear Creek 2004

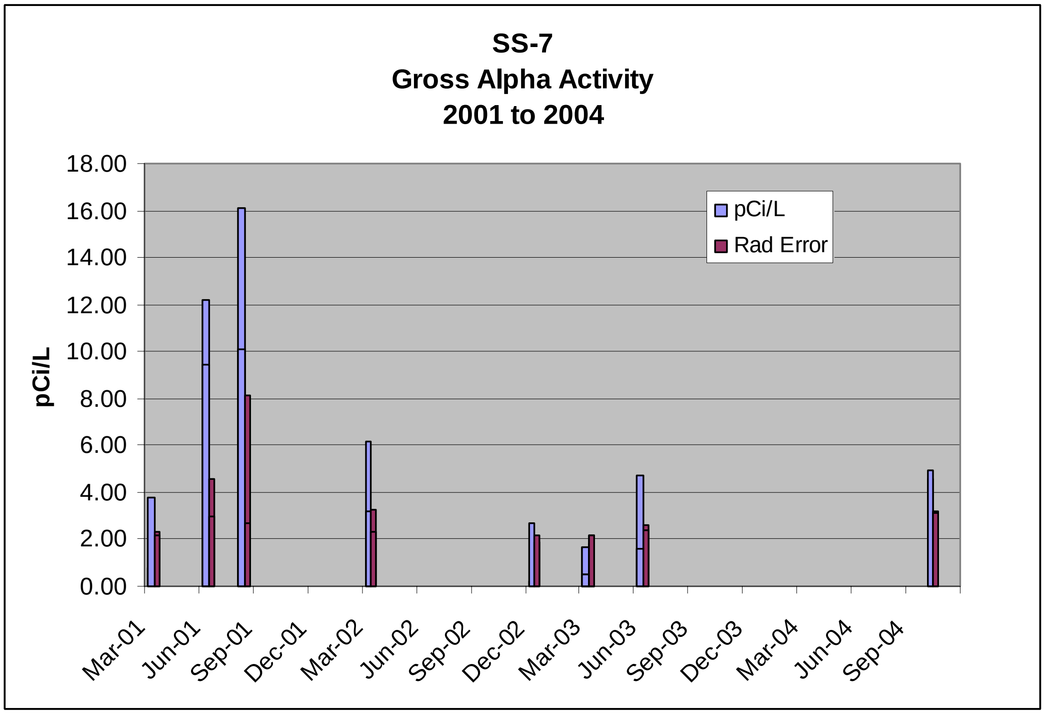

Figure 6, Activity in pCi/L Gross Alpha for Spring SS 7 on Bear Creek 2004

Gross Alpha Flux in the Bear Creek Hydrological System: Previous study results suggest that much of the gross alpha contamination in the waters of Bear Creek Valley are transported from uranium waste disposal areas along individual discrete pathways in surface drainages (e.g., NT-3 & NT-6) or through shallow subsurface fractures such as those that supply the JES Sludge Seep. The vast majority of the contaminant mass is delivered by surface drainages (particularly NT-3).

The gross alpha contaminant mass then follows the gaining and losing reaches of Bear Creek, being lost to the stream in dolines such as the one located at km 11.0 and various other fractures/conduits that exist on the stream bed. It appears that much of the contaminant "lost" from Bear Creek emerges in the series of springs along the base of the northern slope of Chestnut Ridge (in particular spring SS-6) and presumably in gaining reaches of Bear Creek itself. Some of the contaminant mass is probably lost to the deeper Maynardville Aquifer and has been detected from time to time in deep picket wells in this formation.

Conclusions

Most of the uranium in Bear Creek is delivered along discrete, low volume, high concentration flows during the wetter parts of the year. In this regard, tributary NT-3 and JES Seep are particular problems. Uranium also enters the creek through discrete fractures such as JES Seep. This suggests that uranium inputs to the creek can be identified and controlled.

Once in the creek, uranium transport mimics the karst conduit mixed surface and subsurface drainage of the Maynardville Limestone, reemerging in the springs along Chestnut Ridge (after being diluted with water from the Knox Aquifer) and in springs that are integral to the bed of Bear Creek itself. This process of reemergence is substantially completed around spring SS-6 with greatly diminished gross alpha fluxes at SS-7 and SS-8, except during the dryer parts of the year when a lower flow regime dominates the karst system. It should also be considered that in the dryer parts of the year inputs from the karst aquifer underlying Chestnut Ridge have diminished and the entire system loses water to evapotransporation.

Between the point where SS-6 drains into Bear Creek (approximately km 7) and Hwy 95 (km 4.6) the flux of uranium has been seen to decrease, presumably due to neutralization of the dissolved phase and loss to the deeper aquifer.

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CHAPTER 6 SURFACE WATER MONITORING

Rain Event Surface Water Monitoring

Principle Author: Roger Petrie

Abstract
The DOE Oversight Division conducted surface water sampling at six sites on the Oak Ridge Reservation (ORR) in 2004. Samples were collected once per quarter following a qualifying rain event. Most results were consistent with results following a heavy rain. One exception was elevated radiological results from Melton Branch. Results here were elevated due to remedial activities taking place in Melton Valley. Follow up sampling conducted at this site have shown decreasing levels of radiological contamination.

Introduction
Due to the presence of areas of extensive point and non-point source contamination on the Oak Ridge Reservation (ORR), there exists the potential for contamination to impact surface waters on the ORR during excessive rain events. These events could cause the displacement of contamination that would not normally impact streams around the ORR.

To assess the degree of surface water impact caused by these rain events, a sampling of streams will be conducted following heavy rain events to determine the presence or absence of contaminants of concern. Table 1 shows locations that have been selected for sampling.

Table 1. Sample Locations

Site	Location
EFK 23.4	Station 17
WCK 3.0	White Oak Creek at Lagoon Road
MEK 0.1	Melton Branch Weir
MIK 0.1	Mitchell Branch Weir
BCK 4.5	Bear Creek Weir at Hwy. 95
MBK 1.6	Mill Branch (Reference)

Methods and Materials
Once per quarter, surface water samples were collected from the selected sites and analyzed for the following parameters

Inorganics: arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, zinc, nitrogen (NO_2 & NO_3), ammonia, nitrogen (total Kjeldahl), total phosphates
Other tests: E. coli, Enterococcus, dissolved residue, suspended residue, and total hardness
Radionuclides: Gross alpha, gross beta, gamma radionuclides

The dates of collection are shown in Table 2 along with the amount of rainfall received.

Table 2. Dates of Collection and Amounts of Rainfall

Date	Rainfall
3/16/2004	1.5"
4/13/2004	1.5"
9/8/2004	2"
10/20/2004	1.5"

Results

Results of the microbiological analysis of the samples were as expected for samples taken following a rain event. High levels of E. coli and Enterococcus were observed. The results are shown in Table 3.

Table 3. Results of Microbiological Analysis

Site	Date	E. Coli	Enterococcus
		cfu/100mL	cfu/100mL
EFK 23.4	3/16/2004	201	517
WCK 3.0	3/16/2004	1414	>2419
MEK 0.1	3/16/2004	548	74
BCK 4.5	3/16/2004	517	980
MIK 0.1	3/16/2004	816	1120
MBK 1.6	3/16/2004	250	10
EFK 23.4	4/13/2004	980	2419
WCK 3.0	4/13/2004	2419	2419
MEK 0.1	4/13/2004	866	173
BCK 4.5	4/13/2004	816	15
MIK 0.1	4/13/2004	921	2419
MBK 1.6	4/13/2004	365	1
EFK 23.4	9/8/2004	921	2419
WCK 3.0	9/8/2004	1986	2419
MEK 0.1	9/8/2004	1986	2419
BCK 4.5	9/8/2004	2419	2419
MIK 0.1	9/8/2004	2419	2419
MBK 1.6	9/8/2004	1553	2419
EFK 23.4	10/20/2004	197	219
WCK 3.0	10/20/2004	517	113
MEK 0.1	10/20/2004	649	479
BCK 4.5	10/20/2004	1203	2419
MIK 0.1	10/20/2004	435	1203
MBK 1.6	10/20/2004	238	268

Results of the routine parameters were also as expected for samples taken following a rain event. The results are shown in Table 4.

Table 4. Results of Routine Parameters Analysis

Site	Date	Hardness (mg/L)	Residue, dissolved (mg/L)	Residue, suspended (mg/L)
EFK 23.4	3/16/2004	126	160	U
WCK 3.0	3/16/2004	107	151	36
MEK 0.1	3/16/2004	88	120	54
BCK 4.5	3/16/2004	87	115	60
MIK 0.1	3/16/2004	105	128	11
MBK 1.6	3/16/2004	49	67	17
EFK 23.4	4/13/2004	121	148	11
WCK 3.0	4/13/2004	108	177	37
MEK 0.1	4/13/2004	76	92	91
BCK 4.5	4/13/2004	58	89	80
MIK 0.1	4/13/2004	99	122	20
MBK 1.6	4/13/2004	49	59	28
EFK 23.4	9/8/2004	119	119	146
WCK 3.0	9/8/2004	147	194	12
MEK 0.1	9/8/2004	167	197	18
BCK 4.5	9/8/2004	170	209	53
MIK 0.1	9/8/2004	140	144	U
MBK 1.6	9/8/2004	113	129	U
EFK 23.4	10/20/2004	160	204	U
WCK 3.0	10/20/2004	167	213	U
MEK 0.1	10/20/2004	153	193	U
BCK 4.5	10/20/2004	144	168	77
MIK 0.1	10/20/2004	178	208	U
MBK 1.6	10/20/2004	104	122	U

U – indicates that the analyte was analyzed for but not detected.

The results for nutrient analysis were also as expected for samples taken following a rain event. The results are shown in Table 5.

Table 5. Results of Nutrient Analysis

Site	Date	Ammonia (mg/L)	NO2 & NO3 (mg/L)	Total Kjeldahl (mg/L)	Phosphorus (mg/L)
EFK 23.4	3/16/2004	U	2.44	U	0.07
WCK 3.0	3/16/2004	0.05	0.86	0.12	0.06
MEK 0.1	3/16/2004	U	0.26	0.21	0.04
BCK 4.5	3/16/2004	U	1.35	U	0.02
MIK 0.1	3/16/2004	U	0.2	U	0.01
MBK 1.6	3/16/2004	U	0.11	U	0.02
EFK 23.4	4/13/2004	U	2.08	U	0.031
WCK 3.0	4/13/2004	U	0.3	U	0.031
MEK 0.1	4/13/2004	U	0.32	U	0.019
BCK 4.5	4/13/2004	U	0.58	0.12	U
MIK 0.1	4/13/2004	U	8	0.34	U
MBK 1.6	4/13/2004	U	0.08	U	U
EFK 23.4	9/8/2004	U	1.44	0.44	0.055
WCK 3.0	9/8/2004	U	1.05	0.6	0.089
MEK 0.1	9/8/2004	U	0.25	0.47	0.091
BCK 4.5	9/8/2004	U	0.21	0.2	0.012
MIK 0.1	9/8/2004	U	0.24	0.21	0.051
MBK 1.6	9/8/2004	U	0.09	0.15	0.048
EFK 23.4	10/20/2004	0.02	2.41	0.19	0.049
WCK 3.0	10/20/2004	0.02	2.3	0.28	0.124
MEK 0.1	10/20/2004	0.02	0.23	0.31	0.185
BCK 4.5	10/20/2004	U	8.5	0.5	0.063
MIK 0.1	10/20/2004	0.04	0.78	0.13	0.023
MBK 1.6	10/20/2004	0.02	0.51	0.11	0.026

U – indicates that the analyte was analyzed for but not detected.

The results for metal analysis were also as expected for samples taken following a rain event. The only results that were above normal were the mercury levels in the EFK 23.4 samples. This was expected given the levels of mercury contamination present in East Fork Poplar Creek. The results are shown in Table 6.

Table 6. Results of Metals Analysis

Site	Date	Hg (ug/L)	As (ug/L)	Cd (ug/L)	Cr (ug/L)	Cu (ug/L)	Fe (ug/L)	Pb (ug/L)	Mn (ug/L)	Zn (ug/L)
EFK 23.4	3/16/2004	0.5	U	U	U	5	439	U	65	35
WCK 3.0	3/16/2004	U	U	U	1	3	1310	2	61	4
MEK 0.1	3/16/2004	U	U	U	3	2	2080	2	118	14
BCK 4.5	3/16/2004	U	U	U	3	5	903	2	88	12
MIK 0.1	3/16/2004	U	U	U	2	7	2090	U	63	18
MBK 1.6	3/16/2004	U	U	U	U	1	839	U	76	4
EFK 23.4	4/13/2004	0.56	U	U	U	5	483	U	66	38
WCK 3.0	4/13/2004	U	2	U	2	7	1380	2	43	18
MEK 0.1	4/13/2004	U	U	U	4	3	2910	2	148	16
BCK 4.5	4/13/2004	U	1	U	3	3	2160	2	208	12
MIK 0.1	4/13/2004	U	U	U	2	5	981	1	87	18
MBK 1.6	4/13/2004	U	U	U	1	1	896	U	78	4
EFK 23.4	9/8/2004	0.6	U	U	U	5	U	U	62	39
WCK 3.0	9/8/2004	U	U	U	U	4	U	U	46	16
MEK 0.1	9/8/2004	U	U	U	1	2	U	U	154	10
BCK 4.5	9/8/2004	U	U	U	2	2	U	2	81	9
MIK 0.1	9/8/2004	U	U	U	1	6	U	U	29	21
MBK 1.6	9/8/2004	U	U	U	U	1	U	U	64	3
EFK 23.4	10/20/2004	0.3	U	U	U	4	156	U	35	14
WCK 3.0	10/20/2004	U	U	U	U	3	263	U	18	16
MEK 0.1	10/20/2004	U	U	U	U	2	608	U	86	14
BCK 4.5	10/20/2004	U	U	U	2	3	1590	1	108	11
MIK 0.1	10/20/2004	U	U	U	1	2	357	U	87	12
MBK 1.6	10/20/2004	U	U	U	U	U	386	U	49	5

U – indicates that the analyte was analyzed for but not detected.

The results of the gross alpha, gross beta, and gamma radionuclide scan are shown in Table 7. These results are similar to those seen at these sites during normal conditions. The presence of low levels of Cs-137 at the WCK 3.0 site is expected. These levels of Cs-137 also account for the elevated levels of gross beta seen at the site. The one exception is the very high levels of gross beta noted at MEK 0.1 on 9/8/04 and 10/20/04. These levels are significantly higher than levels seen here in the recent past. Due to these elevated levels, follow up sampling is being conducted.

Table 7. Results of Gross Alpha/Beta and Gamma Radionuclide Analysis

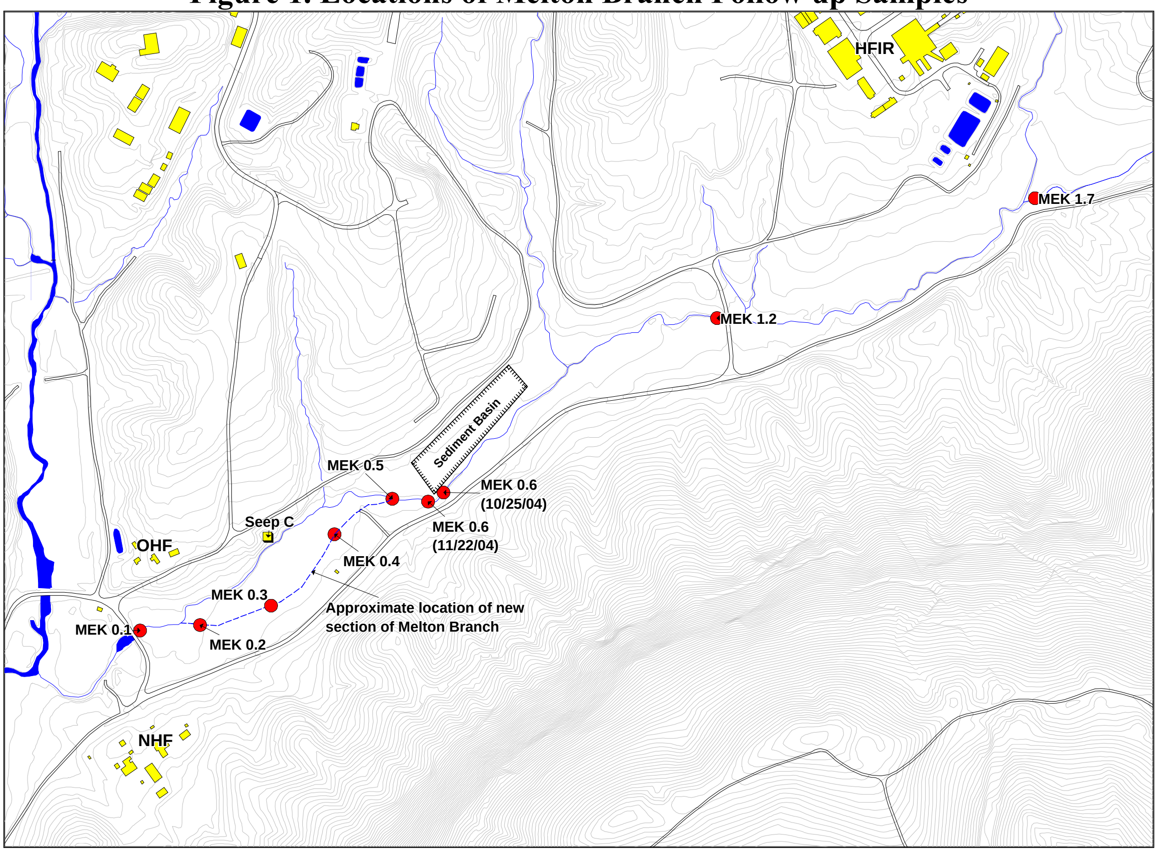
Site	Date	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Cs-137 (pCi/L)	Pb-214 (pCi/L)	Bi-214 (pCi/L)
EFK 23.4	3/16/2004	15.2 ± 4.9	6.4 ± 3.1		18.3 ± 3.2	23.4 ± 3.9
WCK 3.0	3/16/2004	-0.4 ± 3.8	42.2 ± 5.0	7.8 ± 1.7		35.9 ± 4.8
MEK 0.1	3/16/2004	-8.3 ± 4.1	349 ± 13		23.3 ± 3.6	17.2 ± 4.0
BCK 4.5	3/16/2004	4.4 ± 3.0	7.6 ± 3.1		38.6 ± 4.1	44.4 ± 4.7
MIK 0.1	3/16/2004	6.8 ± 3.6	5.9 ± 3.0		60.0 ± 5.3	104.3 ± 6.5
MBK 1.6	3/16/2004	-2.0 ± 1.6	2.3 ± 2.5		118.7 ± 6.5	164.6 ± 8.2
EFK 23.4	4/13/2004	15.0 ± 4.1	5.8 ± 3.0		78.7 ± 5.9	104.5 ± 6.8
WCK 3.0	4/13/2004	2.3 ± 2.8	31.5 ± 4.4		28.4 ± 4.1	45.3 ± 4.8
MEK 0.1	4/13/2004	1.6 ± 3.5	237 ± 10		30.8 ± 4.2	57.2 ± 5.6
BCK 4.5	4/13/2004	5.4 ± 2.4	5.7 ± 2.8		44.7 ± 4.8	85.8 ± 6.2
MIK 0.1	4/13/2004	9.5 ± 3.2	6.8 ± 3.0		32.6 ± 4.5	25.6 ± 4.3
MBK 1.6	4/13/2004	0.4 ± 1.3	4.3 ± 2.6		27.0 ± 3.8	40.3 ± 4.6
EFK 23.4	9/8/2004	17.2 ± 4.5	3.9 ± 3.0		11.7 ± 3.3	
WCK 3.0	9/8/2004	11.9 ± 7.7	157.0 ± 8.9	90.9 ± 4.3		
MEK 0.1	9/8/2004	-45 ± 18	2172 ± 31			11.7 ± 3.4
BCK 4.5	9/8/2004	23.0 ± 6.0	24.9 ± 4.3			
MIK 0.1	9/8/2004	14.0 ± 4.0	8.1 ± 3.3			
MBK 1.6	9/8/2004	0.2 ± 2.1	6.0 ± 3.0			
EFK 23.4	10/20/2004	10.9 ± 4.6	5.9 ± 3.2			
WCK 3.0	10/20/2004	-4.0 ± 5.3	107.6 ± 7.4	36.7 ± 3.1		
MEK 0.1	10/20/2004	-25.1 ± 9.7	837 ± 20			
BCK 4.5	10/20/2004	12.0 ± 4.2	7.4 ± 3.2			
MIK 0.1	10/20/2004	15.4 ± 5.2	8.5 ± 3.4			
MBK 1.6	10/20/2004	0.5 ± 2.4	2.6 ± 2.8			

Initially, follow up sampling on Melton Branch was conducted at the regular sampling site, MEK 0.1. In an effort to further isolate the source of contamination, a spatial sampling was conducted on Melton Branch on 10/25/04 and 11/22/04. These samples were analyzed ofr gross alpha, gross beta, gamma radionuclides, Sr-90, and tritium. The results showed no appreciable levels of gross alpha and no appreciable levels of gamma radionuclides. The results of these sampling events are shown in Table 8. The locations of the samples are shown in Figure 1.

Table 8. Melton Branch Follow up Sampling Results

Site	Date	Gross β Activity	Sr 90 Activity	Tritium Activity
		(as pCi/L)	(as pCi/L)	(as pCi/L)
MEK 0.1	10/25/2004	2927 ± 37	908 ± 288	427000 ± 5540
MEK 0.6	10/25/2004	201.5 ± 9.9	59 ± 19	52200 ± 644
MEK 1.2	10/25/2004	5.6 ± 3.1	1.9 ± 1.0	755 ± 189
MEK 1.7	10/25/2004	2.5 ± 2.9	ND	190 ± 178
MEK 0.1	11/22/2004	540 ± 16	212 ± 108	758000 ± 2360
MEK 0.2	11/22/2004	353 ± 13	158 ± 85	281000 ± 1440
MEK 0.3	11/22/2004	315 ± 13	98 ± 36	90700 ± 831
MEK 0.4	11/22/2004	595 ± 17	272 ± 142	211000 ± 1250
MEK 0.5	11/22/2004	3882 ± 43	1676 ± 1011	3600000 ± 5130
MEK 0.6	11/22/2004	24780 ± 106	9306 ± 2915	17100000 ± 11100

Figure 1. Locations of Melton Branch Follow up Samples



Samples at MEK 0.1 have been collected on a weekly basis since 9/20/04 to track the levels of Sr-90. The results of this weekly sampling are shown in Table 9. Prior to 10/25/04, there was no tritium analysis requested. Results for tritium analysis of samples collected after 12/6/04 have not been received yet. The tritium analysis was requested based on elevated levels of tritium being reported in NPDES sample results from locations on Melton Branch and White Oak Creek.

Table 9. Results of Weekly Sampling at MEK 0.1

Date	Gross β Activity (as pCi/L)	Sr 90 Activity (as pCi/L)	Tritium Activity (as pCi/L)
9/8/2004	2172 ± 31	818 ± 254	
9/20/2004	983 ± 21	325 ± 102	
9/27/2004	977 ± 19	335 ± 106	
10/4/2004	1186 ± 24	597 ± 207	
10/11/2004	1192 ± 29	475 ± 148	
10/18/2004	1103 ± 23	413 ± 129	
10/20/2004	837 ± 20	314 ± 125	
10/25/2004	2927 ± 37	908 ± 288	427000 ± 5540
11/1/2004	703 ± 18	291 ± 110	670000 ± 2200
11/8/2004	652 ± 17	218 ± 77	274000 ± 1420
11/15/2004	512 ± 15	182 ± 64	237000 ± 1340
11/22/2004	540 ± 16	212 ± 108	758000 ± 2360
11/30/2004	805 ± 19	286 ± 91	475000 ± 1870
12/6/2004	689 ± 18	236 ± 7.3	399000 ± 1710
12/13/2004	367 ± 13	130 ± 40	
1/11/2005	371 ± 13	115 ± 35	
1/18/2005	362 ± 13	136 ± 54	
1/24/2005	395 ± 14	122 ± 41	

As these results indicate, the source of the Sr-90 and tritium appears to be in the vicinity of MEK 0.6. It is very important to note that the sample collected on 11/22/04 at MEK 0.6 was not collected from the stream. This sample was collected from water that was leaching out from beneath the berm of the temporary sedimentation basin located adjacent to Melton Branch before it reached the stream. On this date, water was being pumped into the basin from the area of Seep C in Melton Valley. The treatment system at Seep C had been deactivated in preparation for the final capping of the SWSA 5 South burial ground.. During the first weeks of December, a diversion trench was constructed at Seep C and the seep was buried in further preparation for the final capping. As can be seen in the results, at this point, Sr-90 levels dropped significantly, to levels consistent with those seen prior to remediation activities in Melton Valley.

Conclusion

Overall, the results indicate that, with the exception of Melton Branch, there appears to be no significant movement of contaminants into the sampled streams due to heavy rainfall events. The results of the follow up sampling on Melton Branch indicate that there was a short term insult to the stream in relation to remediation activities, but that continued activities have reduced this to a point that is consistent with contaminant levels occurring prior to remedial efforts.

CHAPTER 6 SURFACE WATER MONITORING

Ambient Sediment Monitoring Project

Principle Author: John G. Peryam

Abstract

Sediment analysis is a key component of environmental quality and impact assessment for aquatic ecosystems. The Tennessee Department of Environment and Conservation DOE Oversight Division (the division) conducted sediment sampling at 28 sites in 2004. The sediments were analyzed for inorganics, organics, and radiological parameters. Since there are no federal or state sediment cleanup levels, the data were compared to the Department of Energy's (DOE) Preliminary Remediation Goals (PRGs) for use at the Department of Energy Oak Ridge Operations office. Based on the designation of the water bodies involved, the values were compared to the recreational PRGs. Under recreational land use, individuals are assumed to be exposed to contaminated media while playing, fishing, hunting, or engaging in other outdoor activities. Exposure could result from ingestion of soil or sediment, inhalation of vapors from soil or sediment, dermal contact with soil or sediment, external exposure to ionizing radiation emitted from contaminants in soil or sediment, and consumption of fish. Based on this comparison, the sediments showed no levels of concern for human health.

Introduction

Many organisms depend upon sediments as their primary habitat. Man-made chemicals and waste materials introduced into aquatic systems are often accumulated in sediments. Sediment analysis is an important aspect of environmental quality and impact assessment for rivers, streams, and lakes. The Tennessee Department of Environment and Conservation's DOE Oversight Division (the division) conducts an ambient sediment monitoring program that monitors 28 sites annually for the purpose of detecting possible contamination from DOE sites. There are 11 sites on the Clinch River and 17 sites on tributaries of the Clinch. Site 2 is a background site and is located upstream of the Oak Ridge Reservation (ORR). Tributaries of the Clinch River make up the other 21 sampling sites. Two of the tributary sites (24, 25) are located upstream of the ORR and serve as background sites.

Sampling was conducted in 2004 during the months of April and May. Samples were analyzed for inorganic, organic and radiological parameters. Since there are no federal or state sediment cleanup levels, the data were compared to the Department of Energy's (DOE) Preliminary Remediation Goals (PRGs) for use at the Department of Energy Oak Ridge Operations office. The PRGs are human health risk assessment figures that are dynamic in nature, changing as new information becomes available. Data are available on request.

Methods and Materials

Sediment samples were taken during April and May using the methods described in the 2004 Ambient Sediment Monitoring Plan. Samples were collected at locations with fine sediments; rocky or sandy areas were not used. River sediment samples were taken with a petite ponar dredge; stream samples were taken with stainless steel spoons. The Tennessee State Laboratories processed the samples, according to EPA approved methods.

Analytical Parameters

Inorganics: aluminum, arsenic, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, and zinc.

Organics (extractables): 1,2,4,5-Tetrachlorobenzene, 1,2,4-Trichlorobenzene, 1-Amino-3-nitrobenzene, 2,4,5-Trichlorophenol, 2,4,6-Trichlorophenol (TCPh), 2,4-Dichlorophenol, 2,4-Dimethylphenol, 2,4-Dinitrophenol, 2,4-Dinitrotoluene, 2,6-Dinitrotoluene, 2-Chloronaphthalene, 2-Chlorophenol, 2-Methylnaphthalene, 2-Nitroaniline, 2-Nitrophenol, 3,3'-Dichlorobenzidine, 4-Bromophenyl phenyl ether, 4-Chloro-3-methylphenol, 4-Chloroaniline, 4-Nitroaniline, 4-Nitrophenol, Acenaphthene, Acenaphthylene, Acetophenone, Aldrin, alpha-BHC, alpha-Endosulfan, Anthracene, Benzaldehyde, Benzo[a]anthracene, Benzo[a]pyrene, Benzo[b]fluoranthene, Benzo[g,h,i]perylene, Benzo[k]fluoranthene, Benzoic acid, Benzyl alcohol, beta-BHC, beta-Endosulfan, Biphenyl, bis(2-chloroethoxy) methane, bis(2-chloroethyl) ether, bis(2-chloroisopropyl) ether, bis(2-ethylhexyl) phthalate (DEHP), bis(n-octyl) Phthalate, Butyl benzyl phthalate, Caprolactam, Carbazole, Chlordane, Chlorophenyl-4 phenyl ether, Chrysene, cis-Chlordane, DDD, DDE, DDT, delta-BHC, Dibenzo[a,h]anthracene, Dibenzofuran, Dibutyl phthalate, Dieldrin, Diethyl phthalate, Dimethyl phthalate, Dinitro-o-cresol, Endosulfan Sulfate, Endrin, Endrin Aldehyde, Endrin ketone, Fluoranthene, C1-C4, Fluorene, C1-C3, gamma-BHC (Lindane), gamma-Chlordane, Heptachlor, Heptachlor epoxide, Hexachlorobenzene, Hexachlorobutadiene, Hexachlorocyclopentadiene, Hexachloroethane, Indeno[1,2,3-cd]pyrene, Isophorone, Methoxychlor, Naphthalene, nitro-Benzene, n-Nitrosodimethylamine, n-Nitrosodiphenylamine, n-Nitrosodipropylamine, o-Cresol, Pcb-aroclor 1221, Pcb-aroclor 1232, Pcb-aroclor 1242, Pcb-aroclor 1248, Pcb-aroclor 1254, Pcb-aroclor 1260, Pcb-aroclor 1262, p-Cresol, Pentachlorophenol (PCP), Phenanthrene, C1-C4, Pyrene, Pyridine, and Toxaphene.

Radiological: gross alpha, gross beta, and gamma radionuclides.

Sampling Stations

Site 2 – Clinch River Mile 52.6: Samples are taken in an area approximately 20 to 40 feet from the west bank of the river. This site is upstream of any possible DOE impacts and is a reference site in this respect. It may, however, show effects of any agricultural, industrial and residential activities upstream. See Figure 1.4.

Site 3 - Melton Hill Park: Samples are taken in an area approximately 40 feet from the west bank of the river. See Figure 1.3.

Site 4 - Grubb Islands: Samples are taken in an area approximately 20 to 40 feet from the west bank of the island (downstream side) on the inside of the bend in the river. The coordinates are approximately 35º 53’ 52” N latitude and -84º 22’ 24” W longitude. See Figure 1.2.

Site 5 - Brashear Island: Samples are taken in an area approximately 20 to 40 feet south of the last sandbar (going downstream) of the river approximately 300 to 400 feet upstream of Brashear Island. The coordinates are approximately 35º 55’ 13” N latitude and -84º 26’ 02” W longitude. See Figure 1.1.

Site 6 - Bull Run Steam Plant: Samples are taken at the upstream end of the skimmer wall. The coordinates are approximately 36º 01’ 28” N latitude and -84º 10’ 02” W longitude. See Figure 1.4.

Site 7 – Clinch River Mile 41.2: Samples are taken in the shallows on the inside of the bend in the river. See Figure 1.3.

Site 8 - Scarboro Creek: Samples are taken about 500 feet upstream of Melton Hill Lake. The coordinates are approximately 35º 58' 59" N latitude and -84º 13' 00" W longitude. See Figure 1.3.

Site 9 - Kerr Hollow Branch: Samples are taken about 200 feet upstream of Melton Hill Lake. The coordinates are approximately 35º 58' 45" N latitude and -84º 13' 37" W longitude. See Figure 1.3.

Site 10 - McCoy Branch: Samples are taken underneath the power lines just upstream from Melton Hill Lake. The coordinates are approximately 35º 57' 57" N latitude and -84º 14' 54" W longitude. See Figure 1.3.

Site 12 - East Fork of Walker Branch: Samples are taken about 300 feet upstream of Melton Hill Lake. The coordinates are approximately 35º 57' 22" N latitude and -84º 15' 58" W longitude. See Figure 1.3.

Site 13 - Bearden Creek: Samples are taken about 300 feet upstream of Melton Hill Lake. The coordinates are approximately 35º 56' 05" N latitude and -84º 17' 01" W longitude. See Figure 1.3.

Site 17 – Unnamed Stream: Samples are taken about 2000 feet upstream of the Clinch River. The coordinates are approximately 35º 54' 14" N latitude and -84º 20' 12" W longitude. See Figure 1.2.

Site 18 - Raccoon Creek: Samples are taken about 1500 feet from the confluence with the Clinch River. The coordinates are approximately 35º 54' 12" N latitude and -84º 21' 05" W longitude. See Figure 1.2.

Site 19 - Ish Creek: Samples are taken about 1500 feet upstream of the Clinch River. The coordinates are approximately 35º 54' 11" N latitude and -84º 21' 33" W longitude. See Figure 1.2.

Site 20 - Grassy Creek: Samples are taken about 200 feet from the confluence with the Clinch River/Grassy Creek Embayment. The coordinates are approximately 35º 54' 36" N latitude and -84º 22' 55" W longitude. See Figure 1.2.

Site 21 – Unnamed Stream: Samples are taken about 75 feet from the confluence with the Clinch River/Grassy Creek Embayment. The coordinates are approximately 35º 54' 36" N latitude and -84º 22' 57" W longitude. See Figure 1.2.

Site 22 – Unnamed Stream: Samples are taken approximately 100 feet from the confluence with the Clinch River. The coordinates are approximately 35º 54' 29" N latitude and -84º 23' 25" W longitude. See Figure 1.2.

Site 23 – Ernie's Creek: This stream is located behind Warehouse Road in Oak Ridge. Samples are taken a short distance upstream of the Clinch River embayment at Clinch River Mile 51.1. The approximate coordinates are 36º 02' 19" N latitude and -84º 12' 47" W longitude. See Figure 1.4.

Site 24 – White Creek: This stream is located in the Chuck Swann Wildlife Management Area in Union County. Samples are taken about one mile upstream of Norris Lake/Clinch River. The approximate coordinates are 36º 20' 47" N latitude and -83º 53' 42" W longitude. See Figure 1.6.

Site 25 – Clear Creek: This stream is located near Norris Dam near Clinch River Mile 77.7 Samples are taken near a water storage facility about one mile upstream of the river. The approximate coordinates are 36º 12’ 49” N latitude and -84º 03’ 33” W longitude. This is a background site. See Figure 1.5.

Site 26 – Clinch River Mile 9.0: Samples are taken just upstream of rock cliffs and downstream of where a creek empties into the river, on the inside of the bend in the river. The coordinates are approximately 35º 54’ 36” N latitude and -84º 26’ 15” W longitude. See Figure 1.1.

Site 27 – Clinch River Mile 7.0: Samples are taken just upstream of where a creek empties into the river, on the inside of the bend in the river. The coordinates are approximately 35º 53’ 37” N latitude and -84º 27’ 46” W longitude. See Figure 1.1.

Site 28 – Clinch River Mile 4.0: Samples are taken near a small island (heron rookery) just downstream of the mouth of the Emory River. The coordinates are approximately 35º 53’ 29” N latitude and -84º 29’ 55” W longitude. See Figure 1.1.

Site 29 – Clinch River Mile 0 .0: Samples are taken near the pole with the green beacon in about 10 feet of water. The coordinates are approximately 35º 51’ 52” N latitude and -84º 32’ 01” W longitude. See Figure 1.1.

Site 30 – Tennessee River Mile 569 (one mile upstream of Clinch River mouth): The coordinates are approximately 35º 50’ 43” N latitude and -84º 32’ 23” W longitude. See Figure 1.1.

Site 31 – Tennessee River Mile 567 (one mile downstream of Clinch River mouth): The coordinates are approximately 35º 51’ 38” N latitude and -84º 32’ 38” W longitude. See Figure 1.1.

Site 32 – Clinch River Mile 19.7 (below Jones Island): The coordinates are approximately 35º 54’ 03” N latitude and -84º 21’ 02” W longitude. See Figure 1.2.

Site 33 – Poplar Creek Mile 0.5: The coordinates are approximately 36º 01’ 03” N latitude and -84º 14’ 21” W longitude. See Figure 1.1.

Site 34 – Walker Branch: The coordinates are approximately 35º 57’ 10” N latitude and -84º 16’ 25” W longitude. See Figure 1.3.

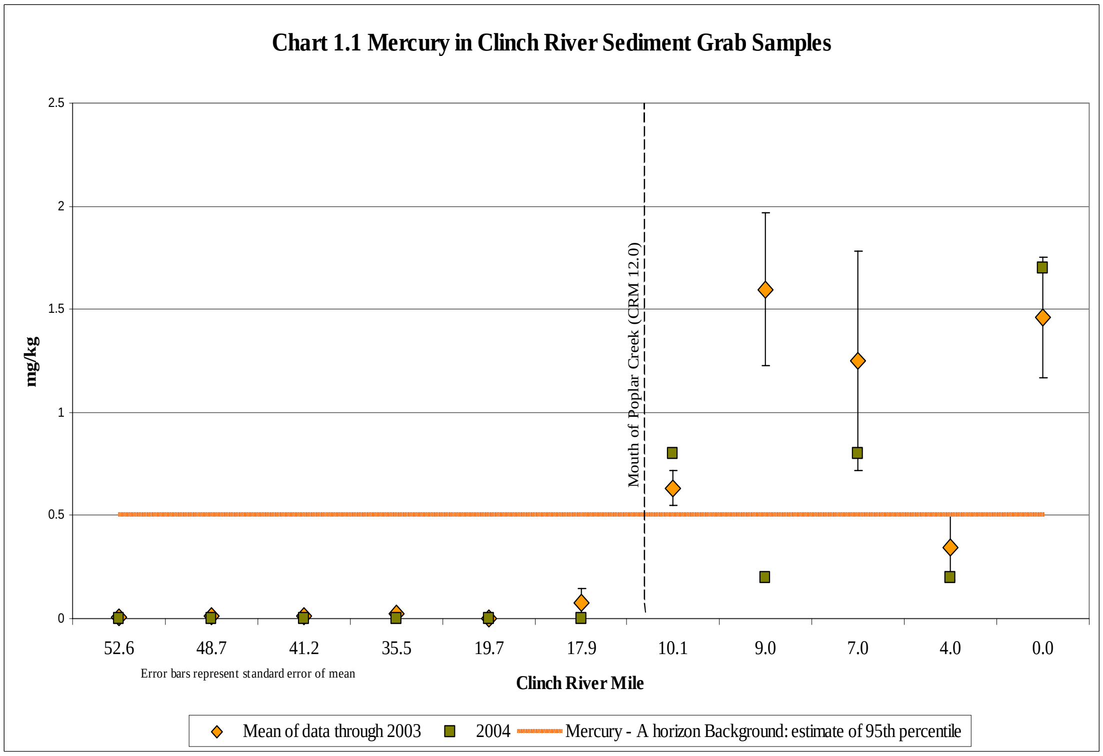
Site 35 – Unnamed Stream: The coordinates are approximately 35º 54’ 04” N latitude and -84º 21’ 59” W longitude. See Figure 1.2.

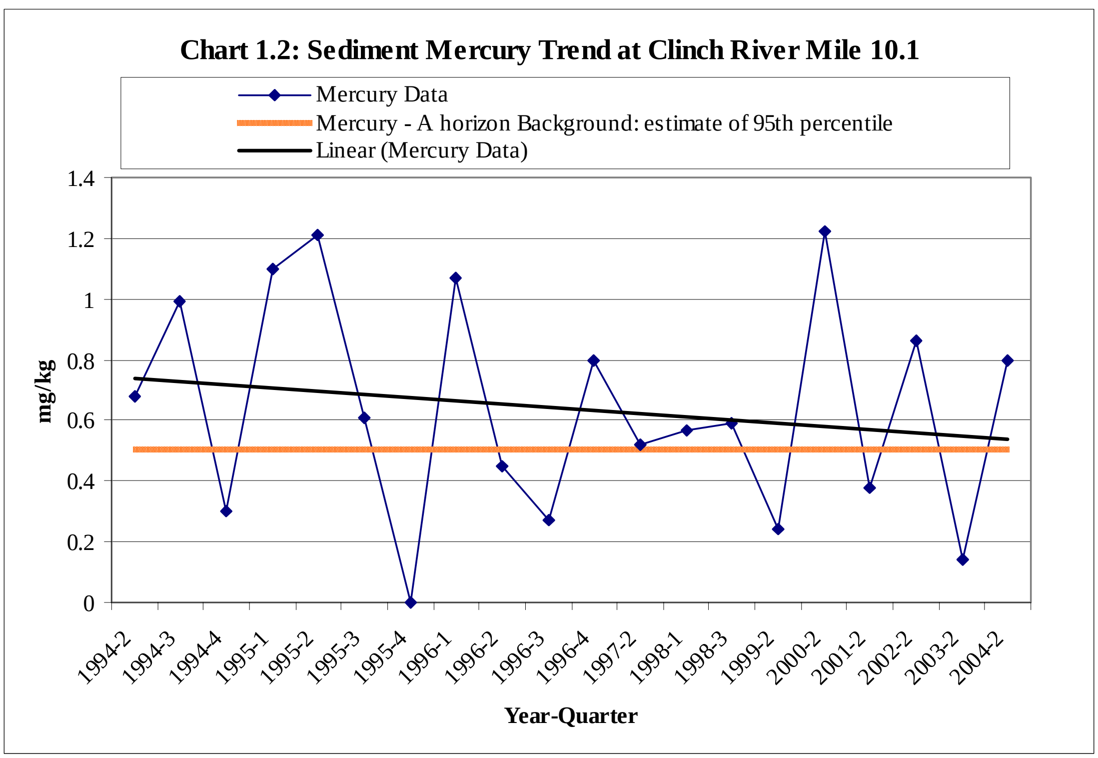
Results and Discussion

Inorganics Analyses

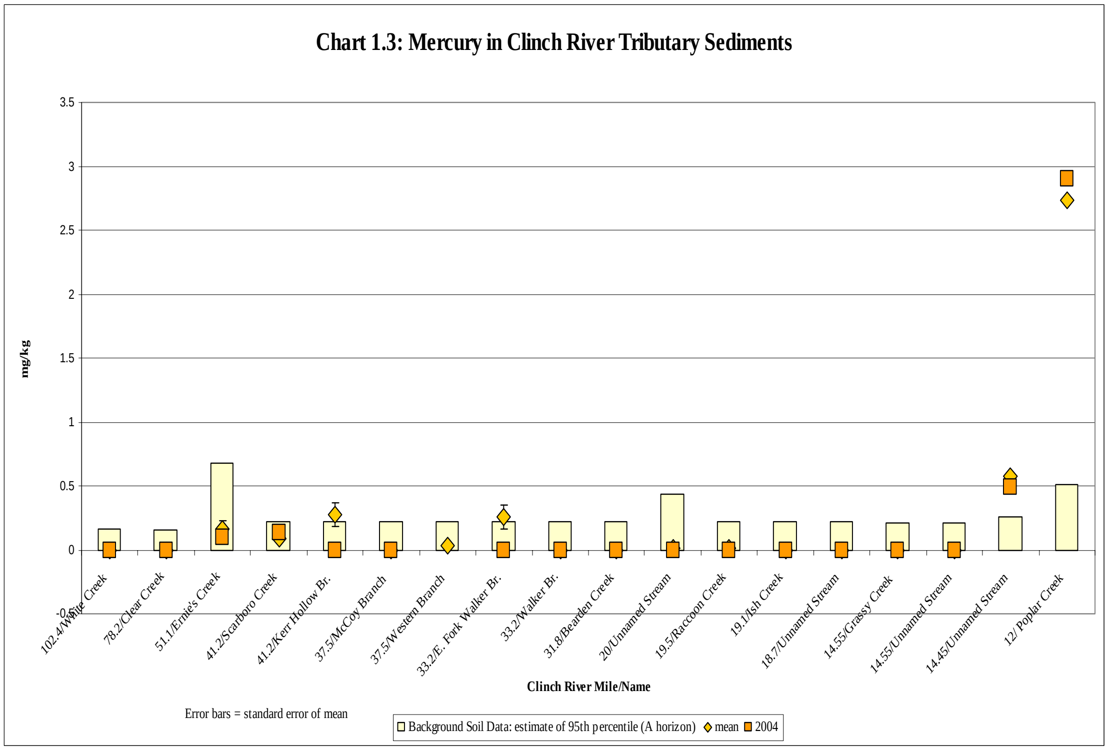
Inorganic analyses of sediment samples taken in 2004 showed no levels of concern based on comparisons with DOE’s Preliminary Remediation Goals (PRGs) for recreation use of soils and sediments. PRGs are used for comparison because there are no state or federal sediment criteria.

Mercury levels in the samples taken in the Clinch River below the confluence of Poplar Creek (sites 5, 26, 27, 28, and 29: river miles 10.1, 9.0, 7.0, 4.0, and 0.0, respectively) increase as one goes downstream. Although the levels of mercury are well below the recreational Total Soil PRG (778 mg/kg), they are higher than all of the other sediment sampling sites (see Chart 1.1). Mercury is virtually undetectable at the sites upstream of the mouth of Poplar Creek; this is why the data points for the means are obscured by the 2004 data points at Clinch River Miles (CRM) 52.6, 48.7, 41.2, 35.5 and 17.9 in Chart 1.1. The mercury levels at the sites below Poplar Creek are also higher than background soil levels (DOE 1993b). For the purpose of river sediment comparisons, the estimate of the 95th percentile for ORR overall data on pages G-54 to G-56 was used as background. At Clinch River Mile 10.1 the mercury trend is decreasing (Chart 1.2). The trends at the sites farther downstream can be determined in a few years when more data is obtained.



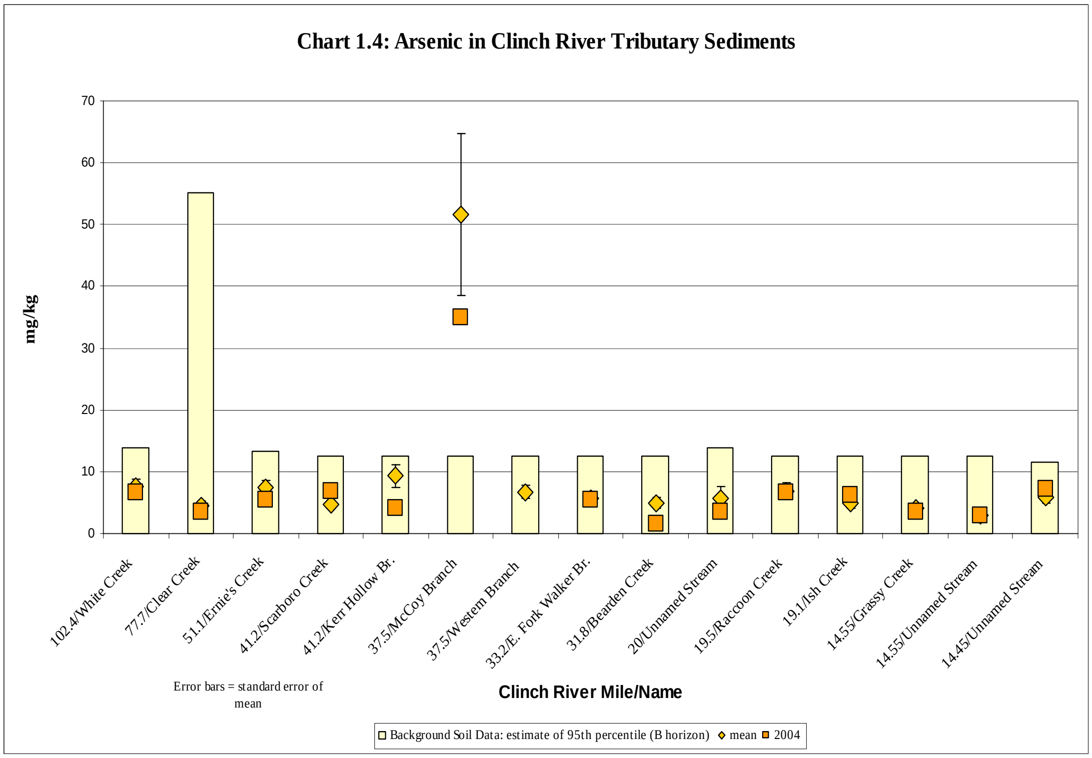


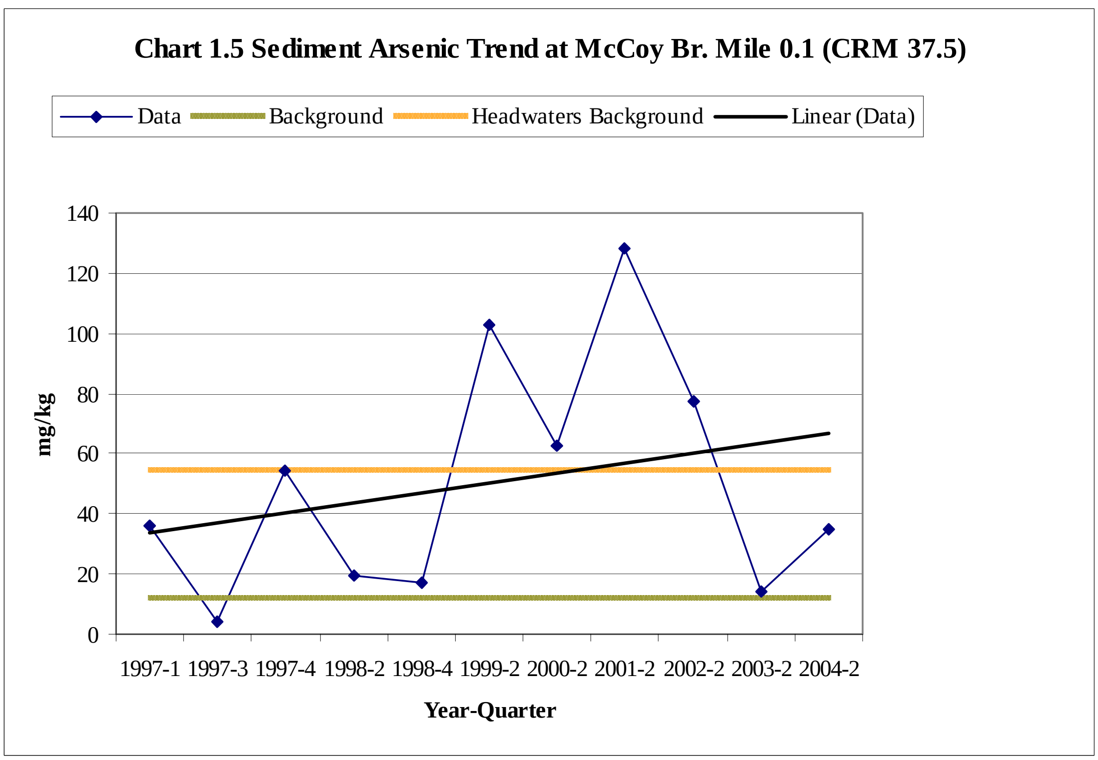
At the Poplar Creek Mile 0.5 (site 33), mercury is above background (Chart 1.3). There is insufficient data at the present time to determine what the trend is at this site. Site 22 also shows mercury above background for the Nolichucky-ORR soils with a trend that is almost flat to slightly increasing. This slight elevation may be due to concentration of sediments by the drinking water facility's filters and the subsequent backwashing of these sediments into a lagoon that fed back into the Clinch River. When the mercury numbers at site 22 are compared to the background level used for the River sites (ORR Overall: 0.506 mg/kg)(DOE 1993b) rather than the background level for the geological group it is in (Nolichucky-ORR), they appear normal (DOE 1993a).



Arsenic at McCoy Branch (CRM 37.5) is above background level for Chickamauga-Bethel Valley soils (12.50 mg/kg) (DOE 1993a) but since it has its headwaters on the side of Chestnut Ridge where Knox group soils predominate, it may not be appropriate to compare the arsenic values with the Chickamauga-Bethel Valley background figures (Chart 1.4). The arsenic background value for Knox group soils is much higher (55.1 mg/kg for the B horizon) and is similar to the McCoy Branch site data (DOE 1993a). The trend for arsenic at the McCoy Branch site is slightly upward since sampling was started there in 1997. This may be due to increasing sediment contributions from the Knox group C horizon soils in the headwaters on the side of Chestnut Ridge. The C horizon background for arsenic in Knox Group soils is 131.0 mg/kg (estimate of 95th percentile) (DOE 1993a).

None of the other inorganic parameters were found to be at levels above background soil values.

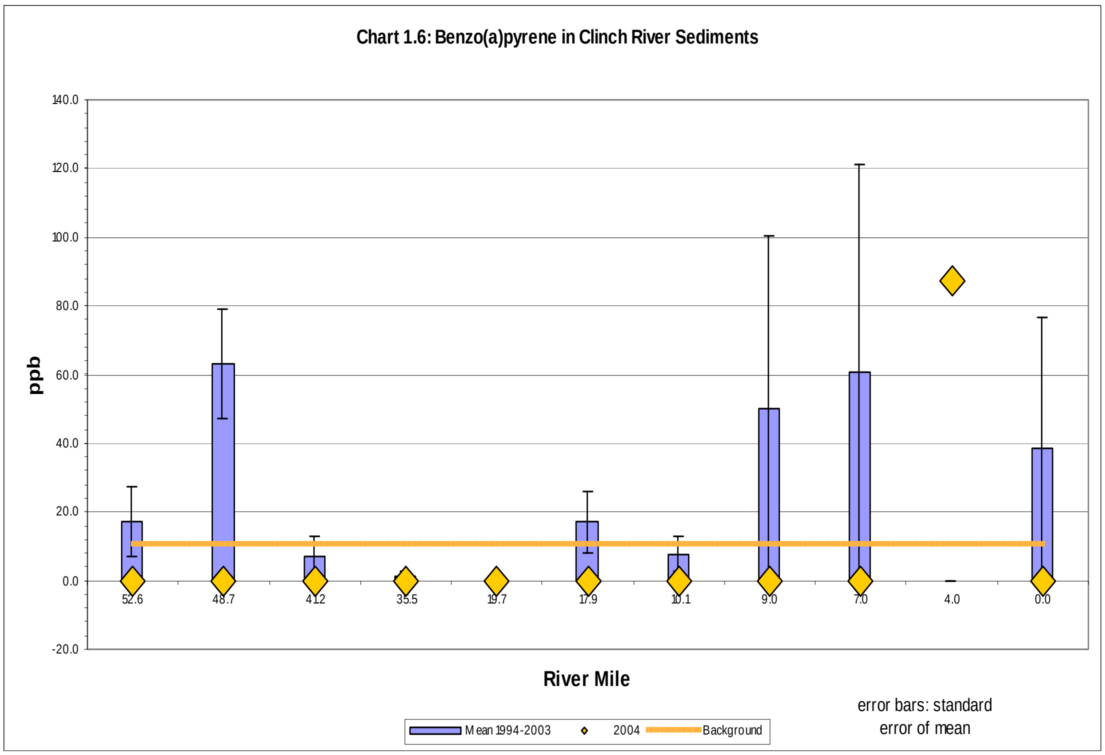


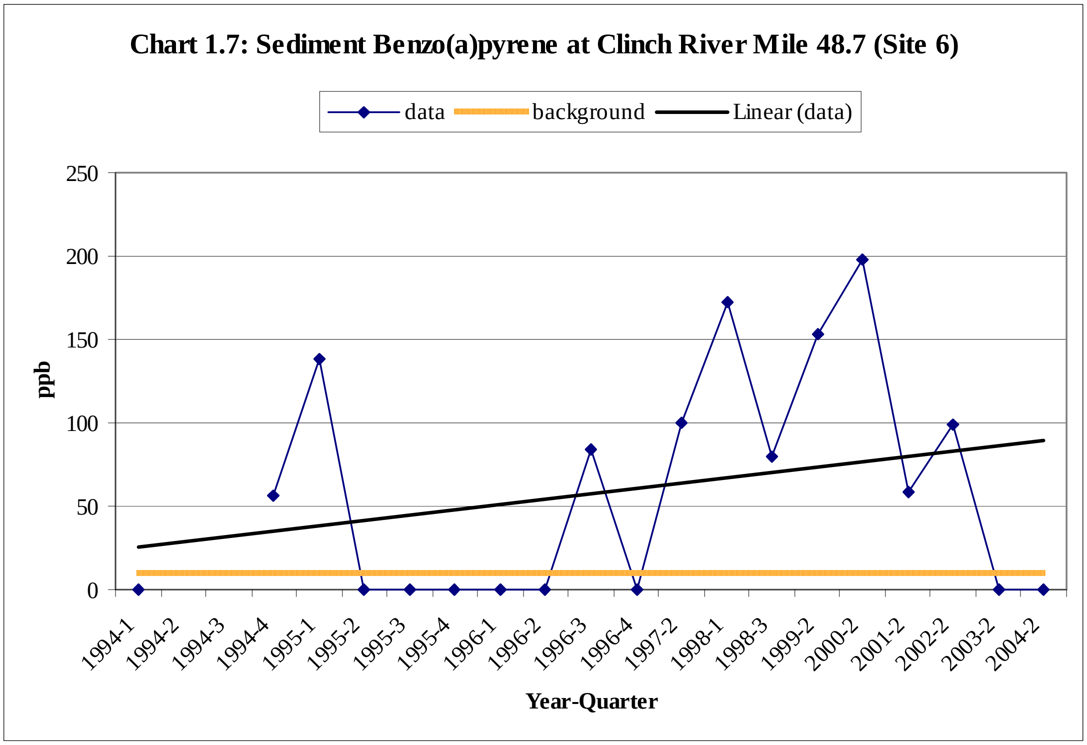


Organics Analyses

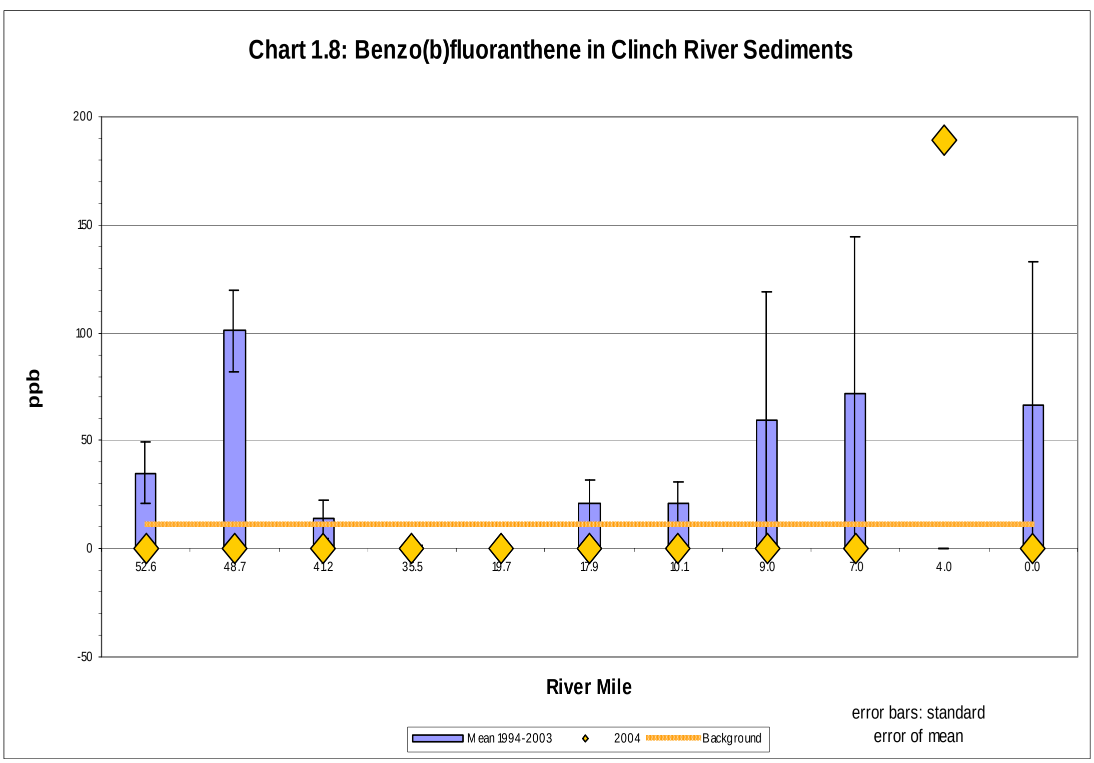
Site number 6 at CRM 48.7 has some polycyclic aromatic hydrocarbons (PAHs) that are above background, but do not pose a threat to human or environmental health. This site is located just upstream from the Bull Run Steam Plant. PAHs are a group of over 100 chemicals that are created during the incomplete combustion of coal, oil and gas, garbage, or other substances like tobacco or charbroiled meat. PAHs are usually found as a mixture of several of these compounds. PAHs are found in coal tar, crude oil, creosote, and roofing tar, but a few are used in the manufacture of medicines, dyes, plastics, and pesticides.

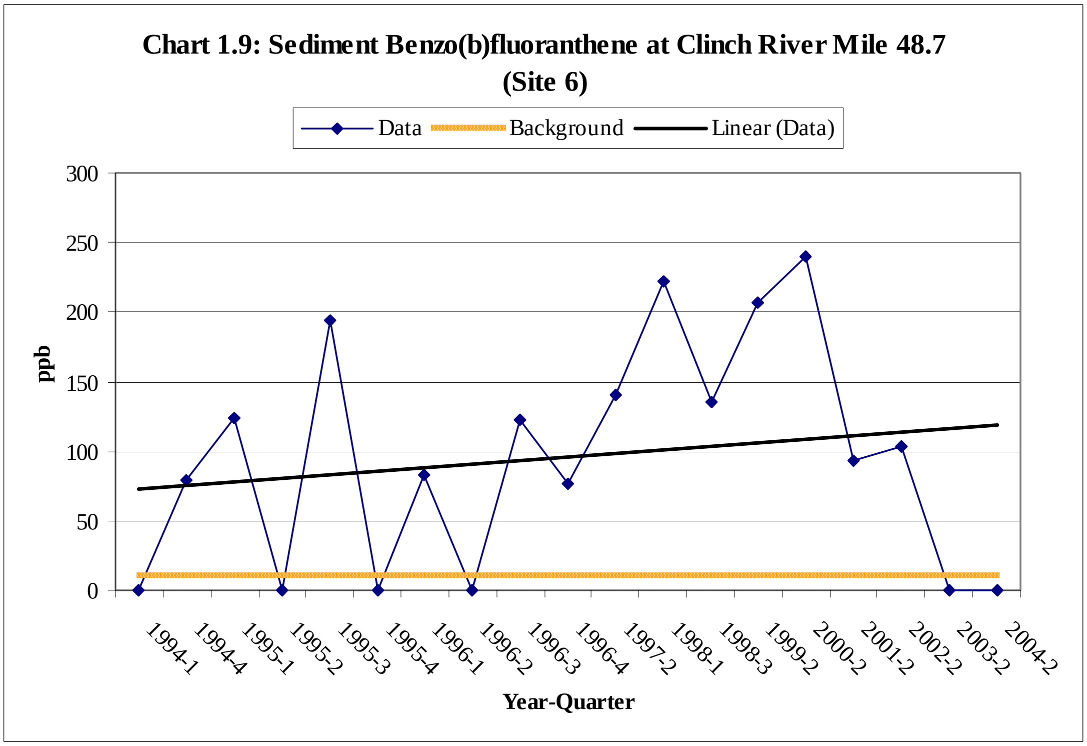
Benzo(a)pyrene is one of these PAHs that are consistently found above background at CRM 48.7 (Chart 1.6). Other sites downstream (CRM 9.0, 7.0, and 0.0) initially appear to be high but the large standard error bars indicate that most of the samples were non-detects. The mean for CRM 48.7 is 63.2 µg/kg with a standard error of 16.1. This is below the Total Soil PRG Risk (1E-06) for benzo(a)pyrene which is 635 µg/kg. The PRG is for soils, whereas the sediments in question are located underwater in 12-20 feet of water just in front of the skimmer wall, a place where people are unlikely to contact them. The source of the elevated PAHs at this site is probably due to an influx of PAHs from Ernie's Creek (site 23) which is located upstream at CRM 51.1. The trend for sediment benzo(a)pyrene is upward for CRM 48.7 (Chart 1.7).



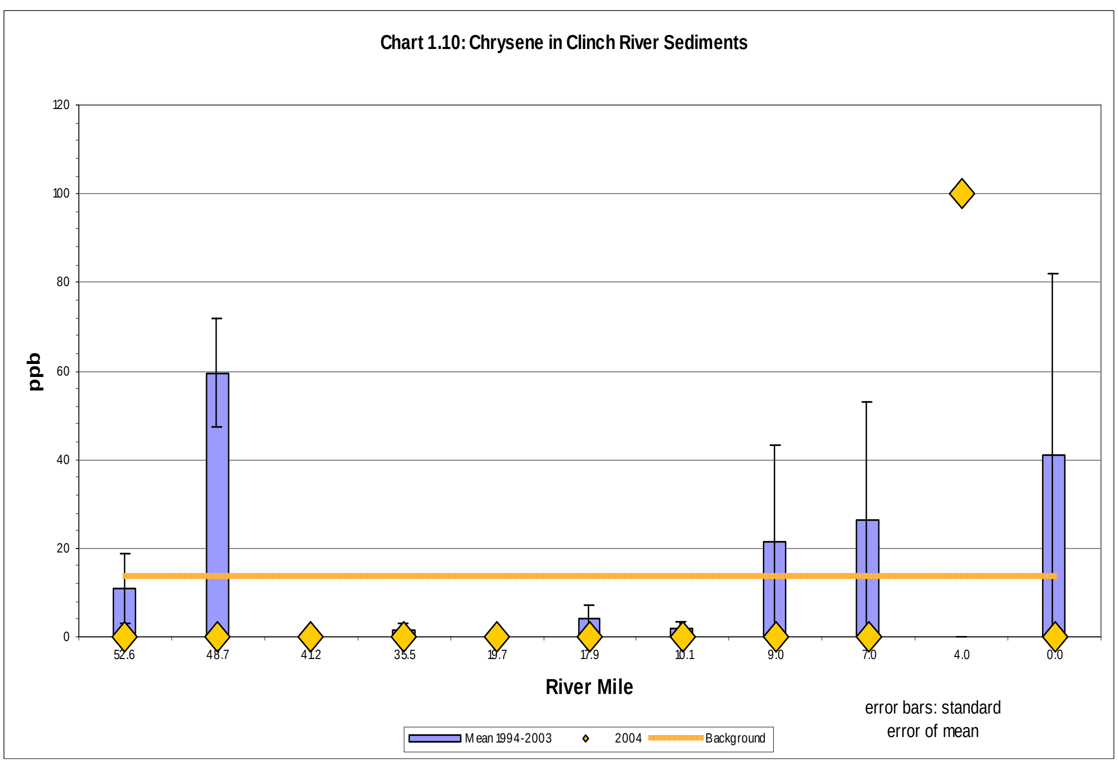


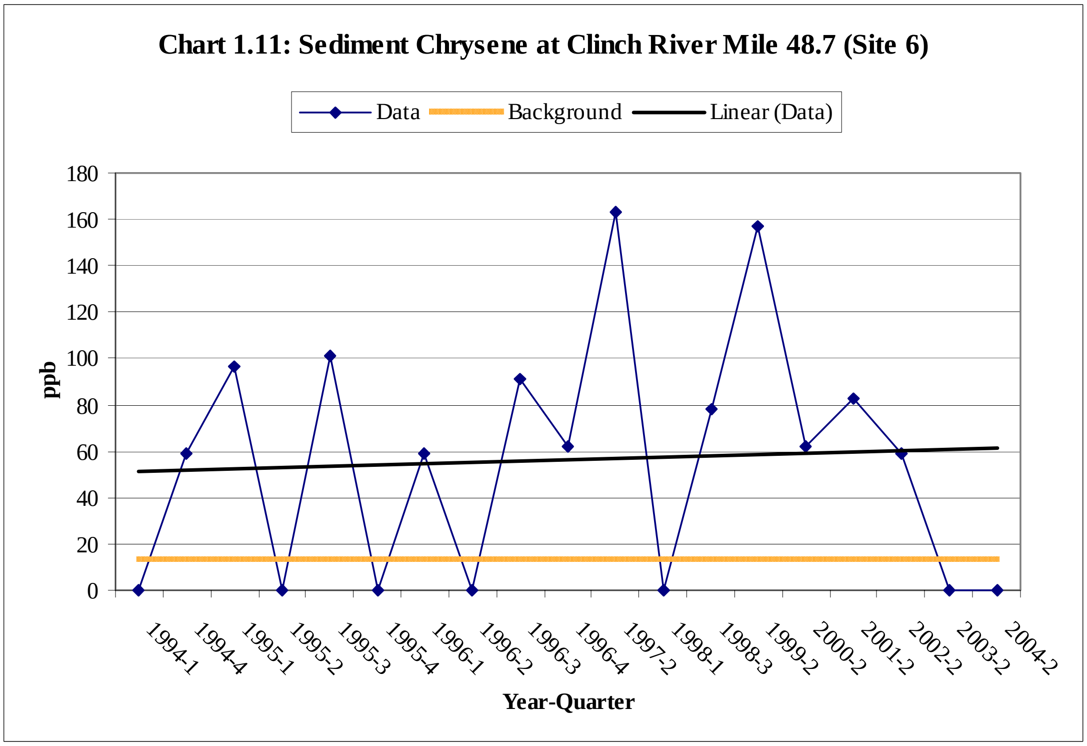
Benzo(b)fluoranthene is also found above background at Site 6 (CRM 48.7) (Chart 1.8). The PRG (total soil risk 1E-06) for benzo(b)fluoranthene is 6350 µg/kg so there is no reason for concern. The trend at this site is increasing (Chart 1.9).

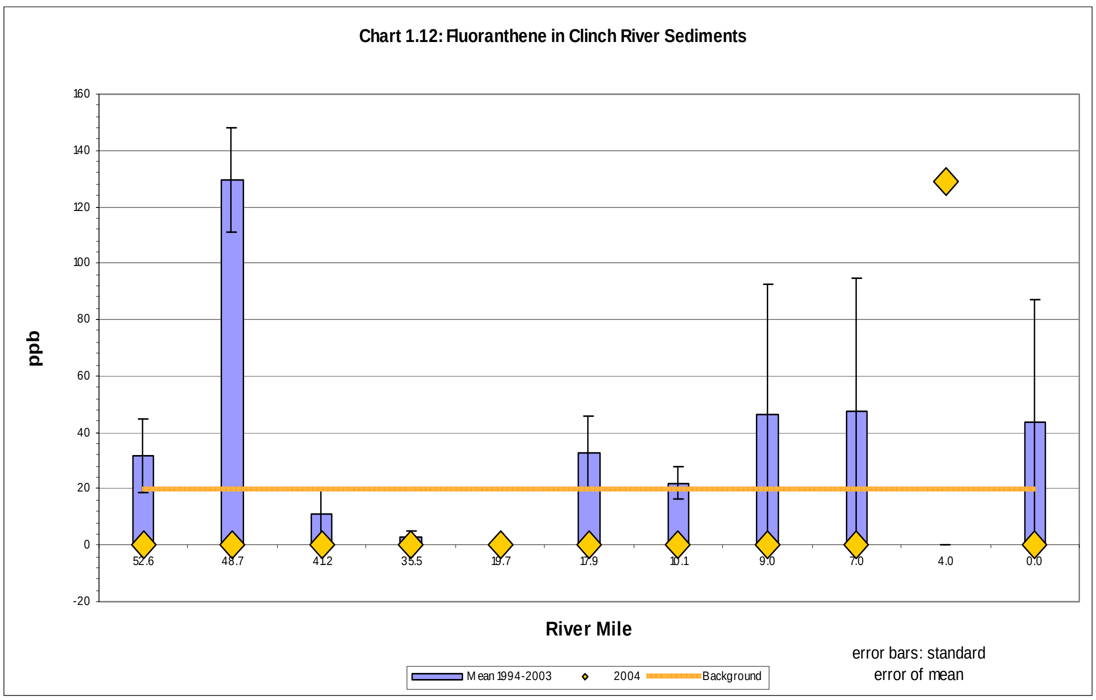




A similar situation occurs at the same site with chrysene (Chart 1.10). The PRG (total soil risk 1E-06) for chrysene is 635,000 µg/kg so there is no reason for concern. The trend at this site is slightly increasing (Chart 1.11).

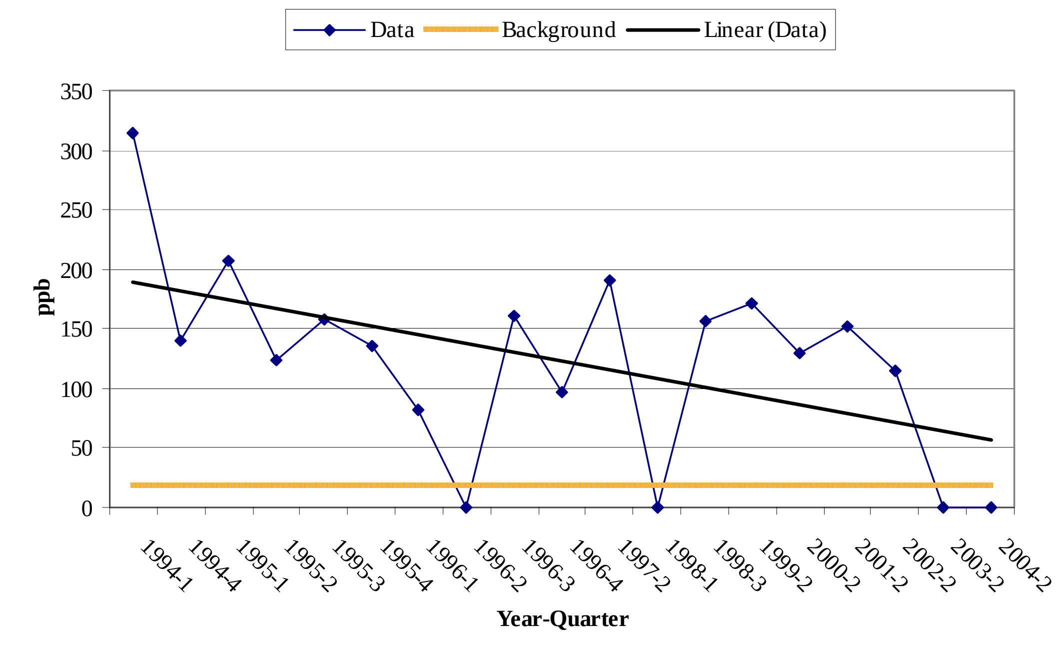






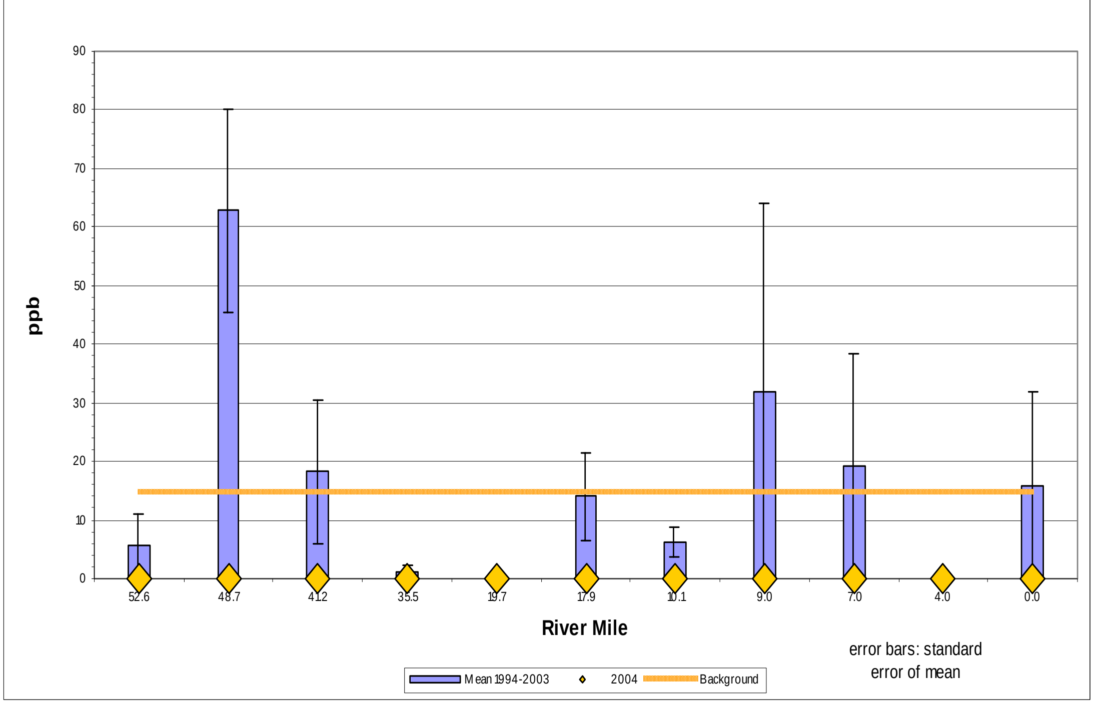
Fluoranthene, another PAH, is also found above background levels at site 6. (Chart 1.12). The PRG (total soil risk 1E-06) for fluoranthene is 79,500,000 µg/kg. At these levels, the fluoranthene in these river sediments do not pose a risk to humans. The trend at this site is decreasing (Chart 1.13).

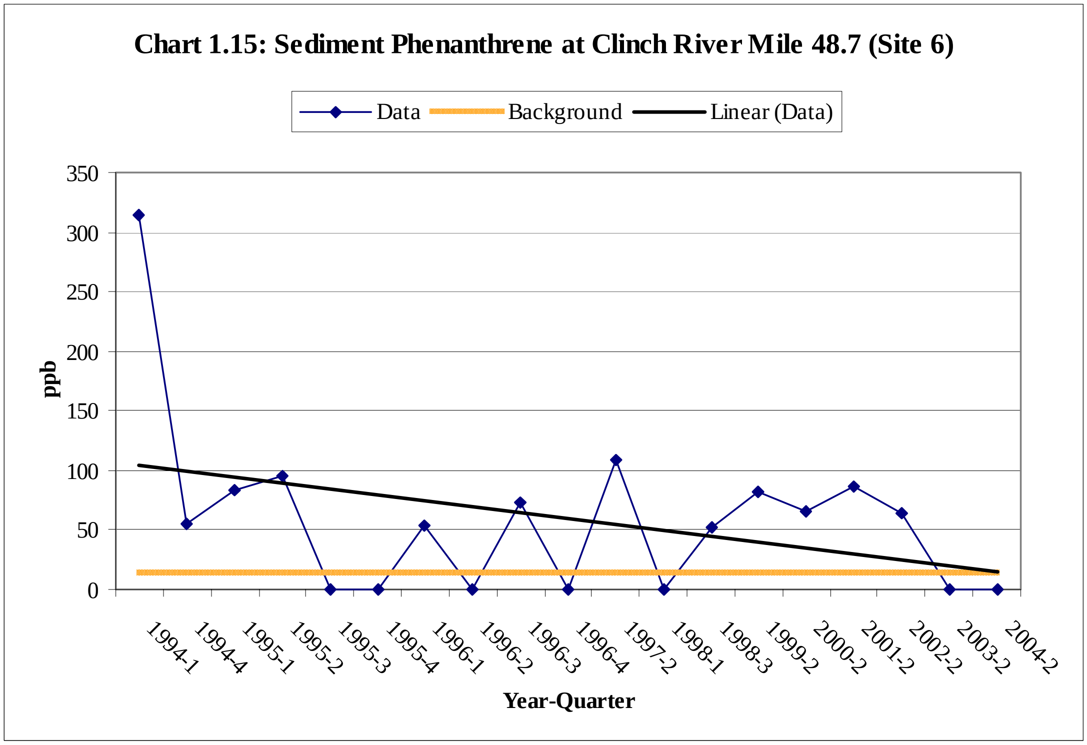
Chart 1.13: Sediment Fluoranthene at Clinch River Mile 48.7 (Site 6)



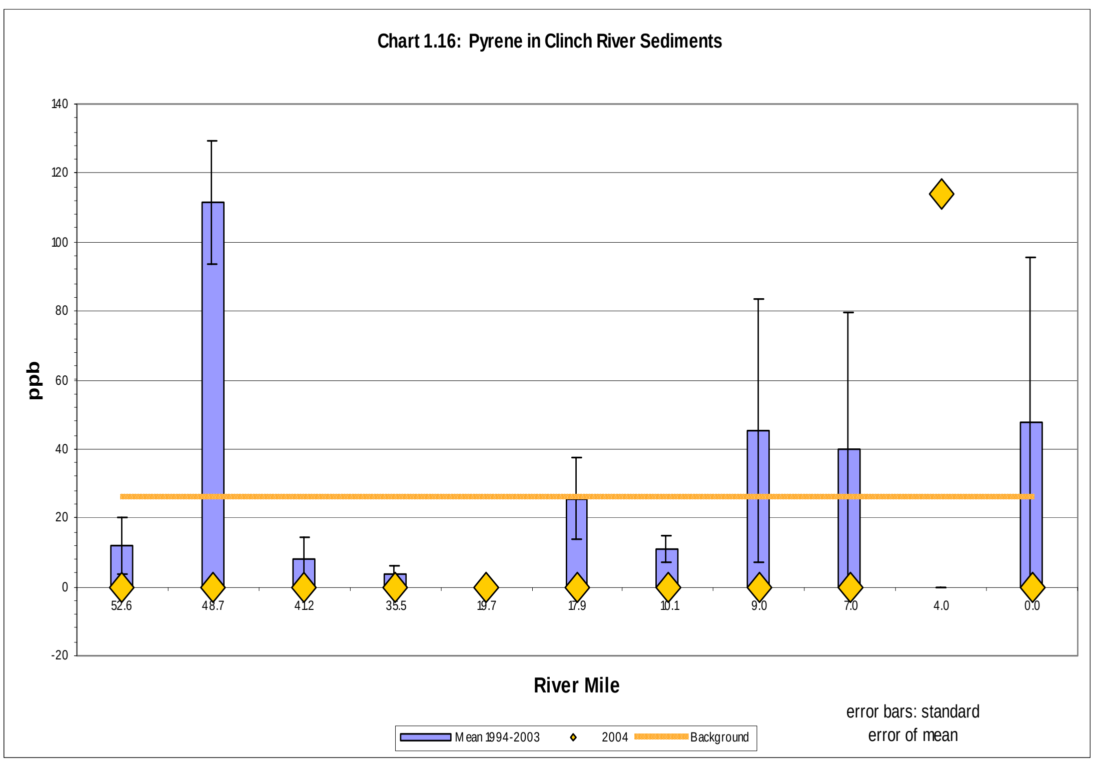
Phenanthrene, another PAH, is also found above background levels at site 6. (Chart 1.14). The trend at this site is decreasing (Chart 1.15).

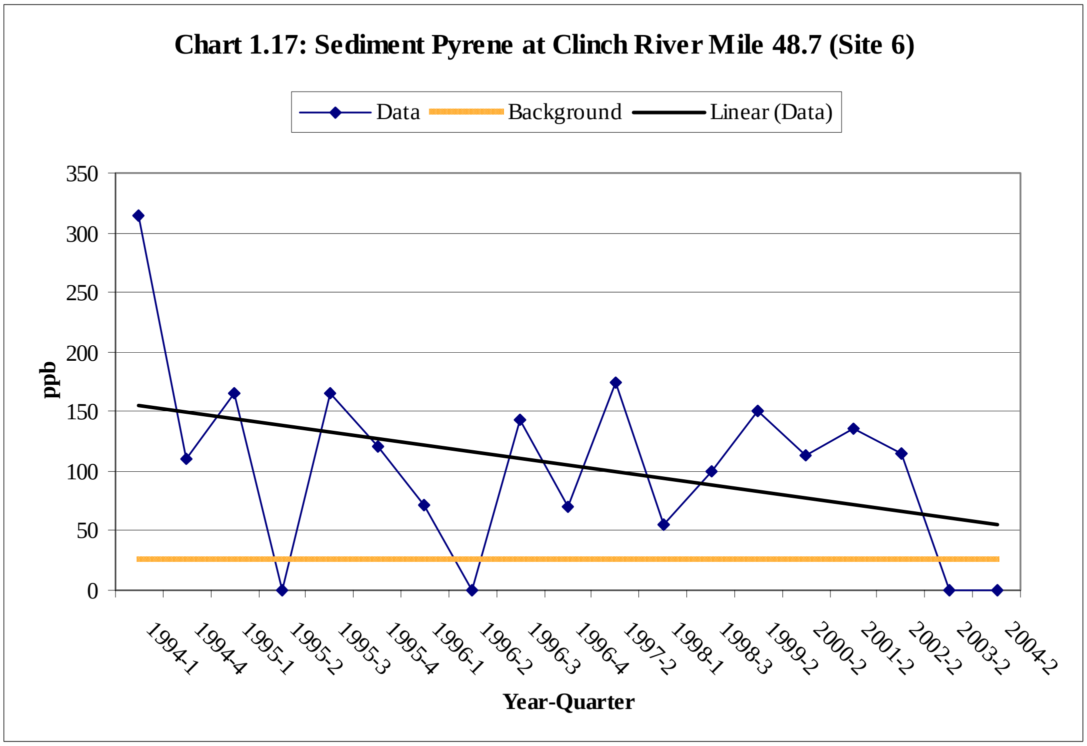
Chart 1.14: Phenanthrene in Clinch River Sediments



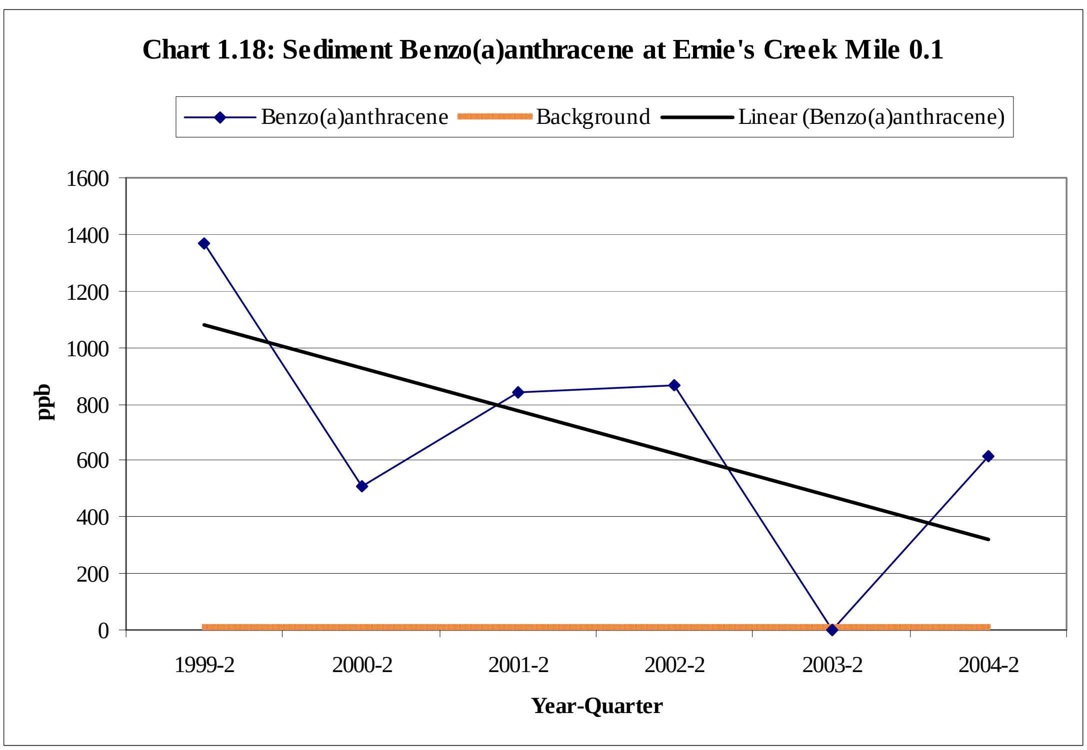


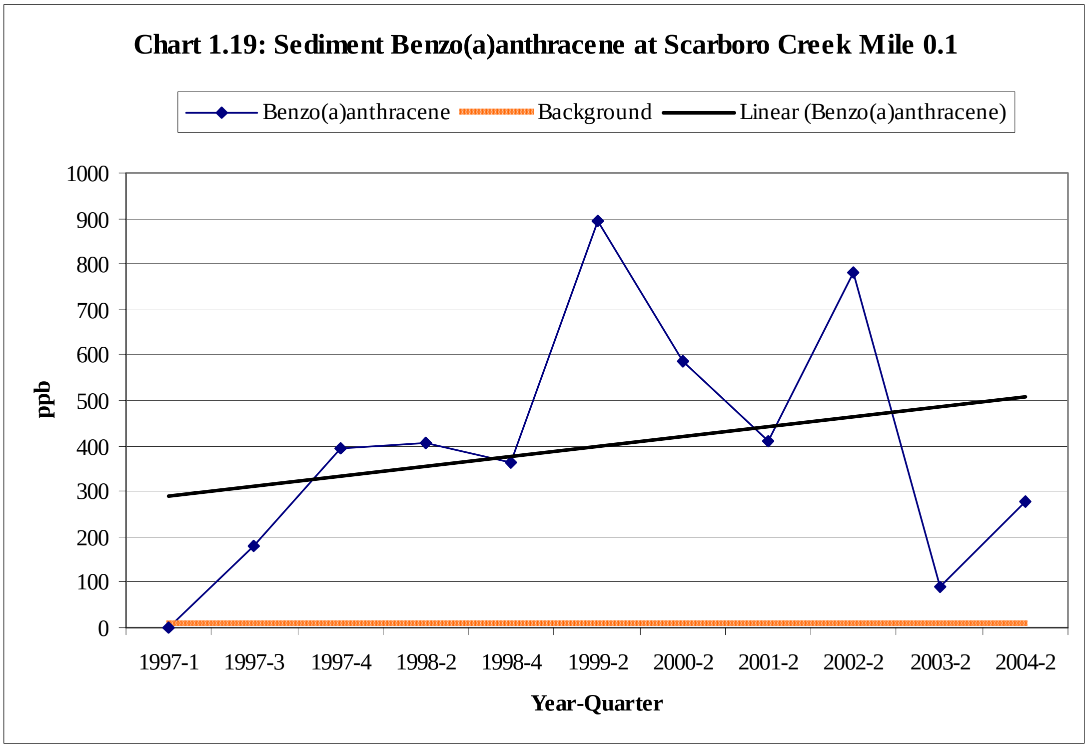
Pyrene is also found above background levels at site 6. (Chart 1.16). The PRG (total soil risk 1E-06) for pyrene is 59,600,000 µg/kg. The trend at this site is decreasing (Chart 1.17).



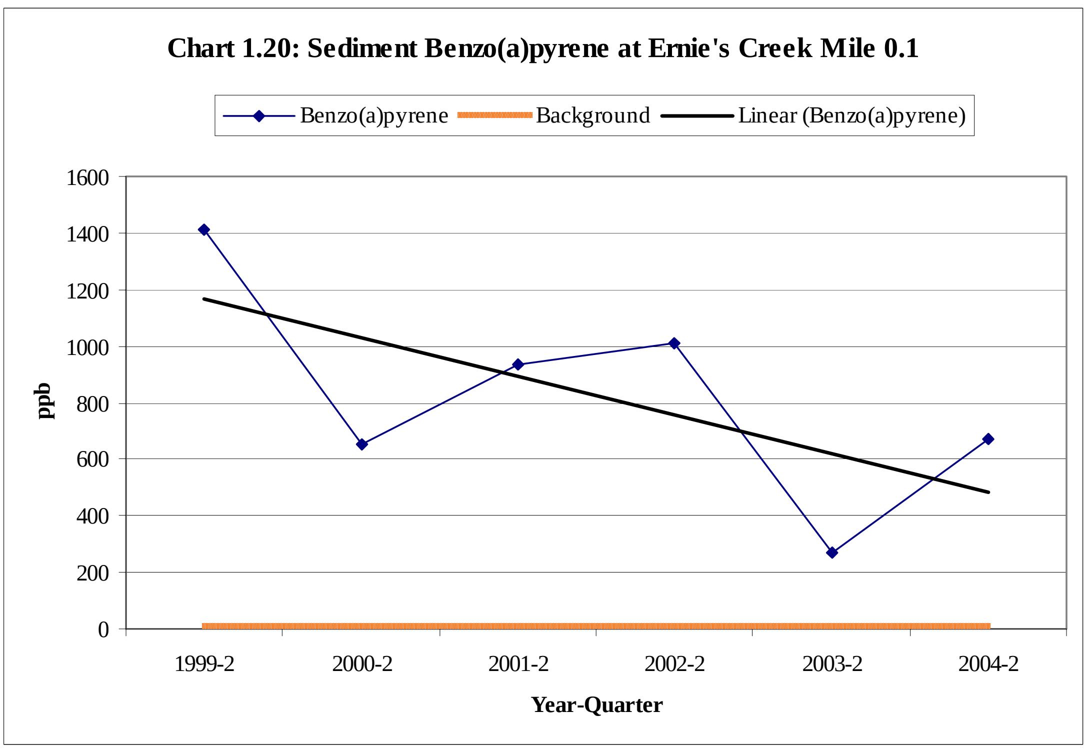


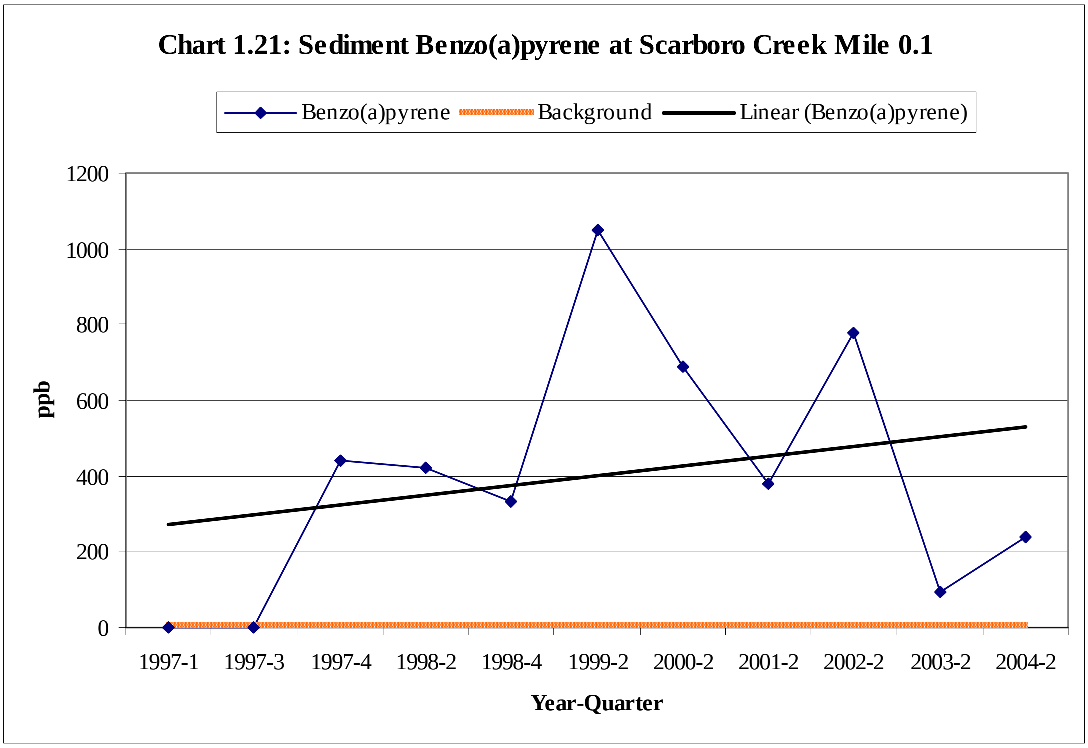
Two of the tributary sites show PAH contamination, Ernie's Creek (site 23) at CRM 51.1 and Scarboro Creek (site 8) at CRM 41.2. Ernie's Creek may have been contaminated by groundwater leakage of an old Oak Ridge landfill on the east side of town. Stormwater drainage from area roads may have also contributed with petroleum products spilled and leaked from vehicles. Scarboro Creek may have been contaminated by groundwater from an old landfill in Union Valley. None of the PAHs at either of these streams are at levels that exceed DOE PRGs but they are well above background soil values. The PRG (total soil risk 1E-06) for Benzo(a)anthracene is 6350 µg/kg. The trend at Ernie's Creek is decreasing (Chart 1.18) while the trend at Scarboro Creek is increasing (Chart 1.19).



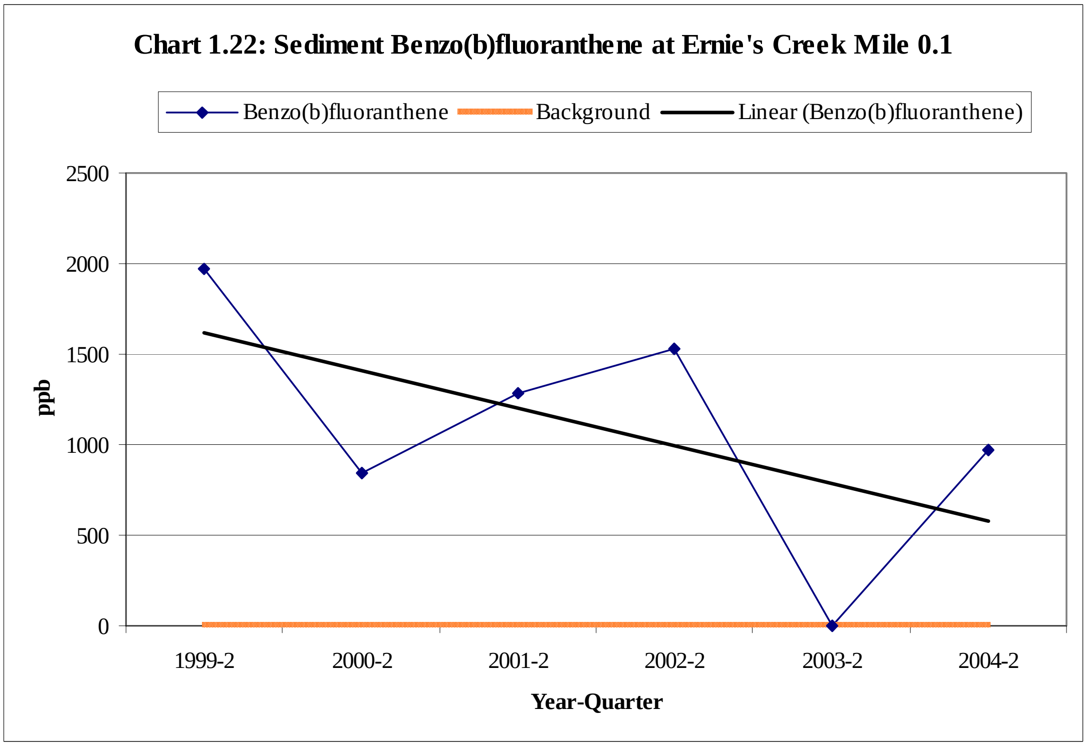


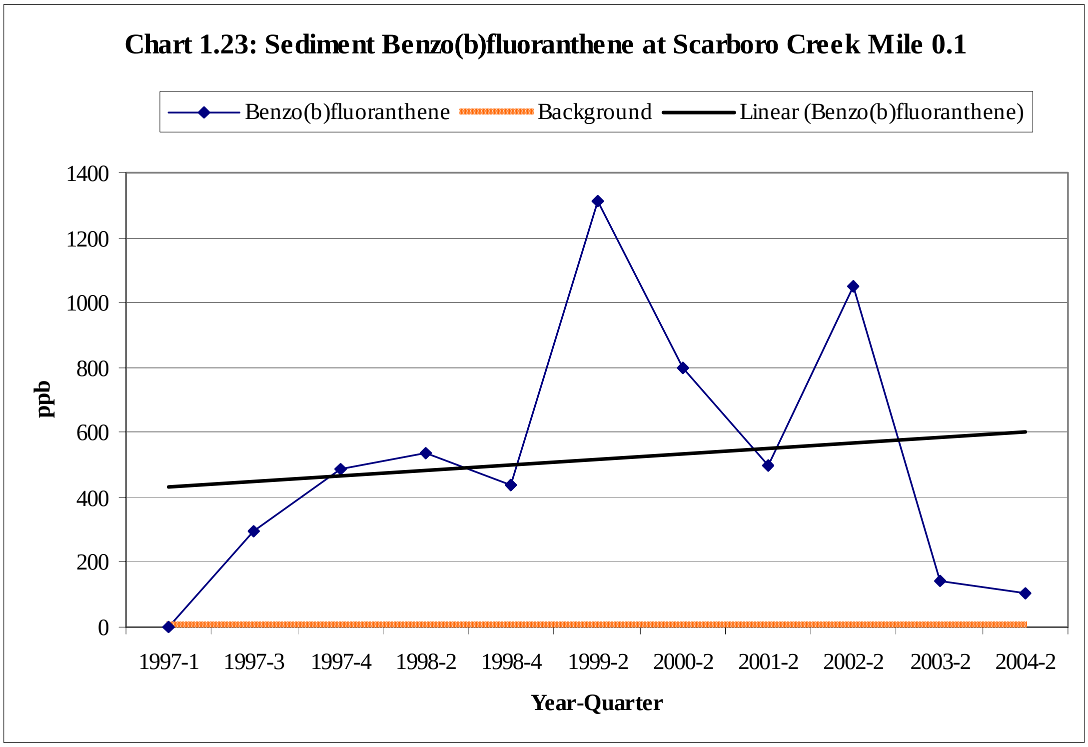
The PRG (total soil risk 1E-06) for Benzo(a)pyrene is 635 µg/kg. The trend at Ernie's Creek is decreasing (Chart 1.20) while the trend at Scarboro Creek is increasing (Chart 1.21).



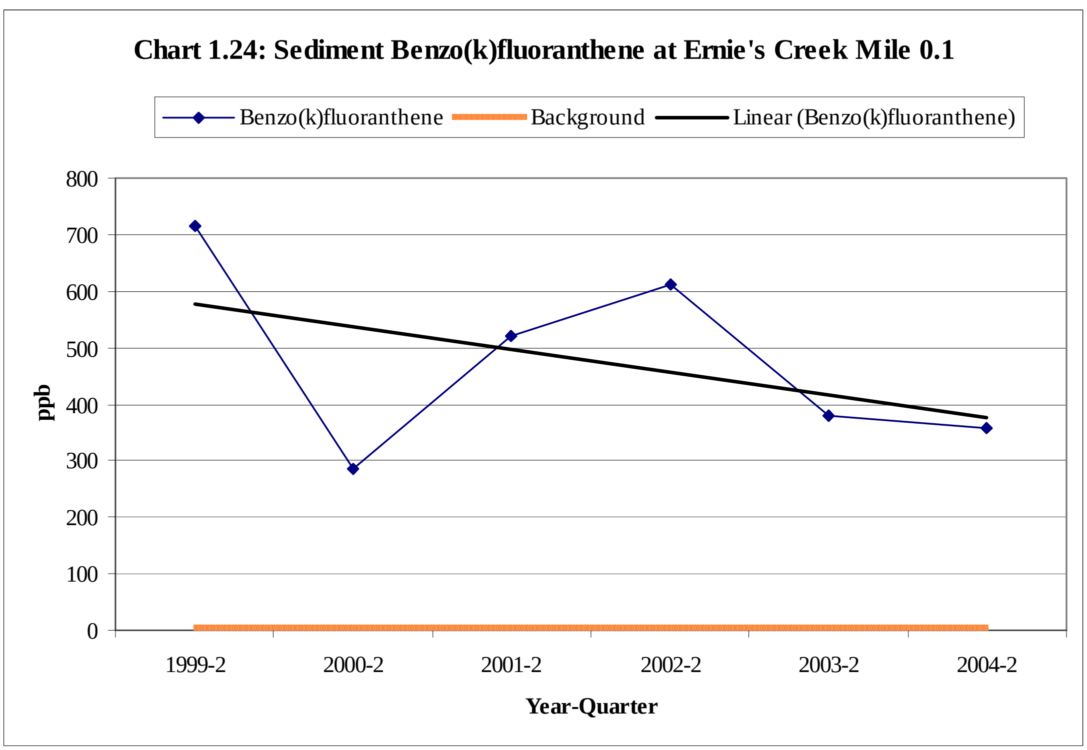


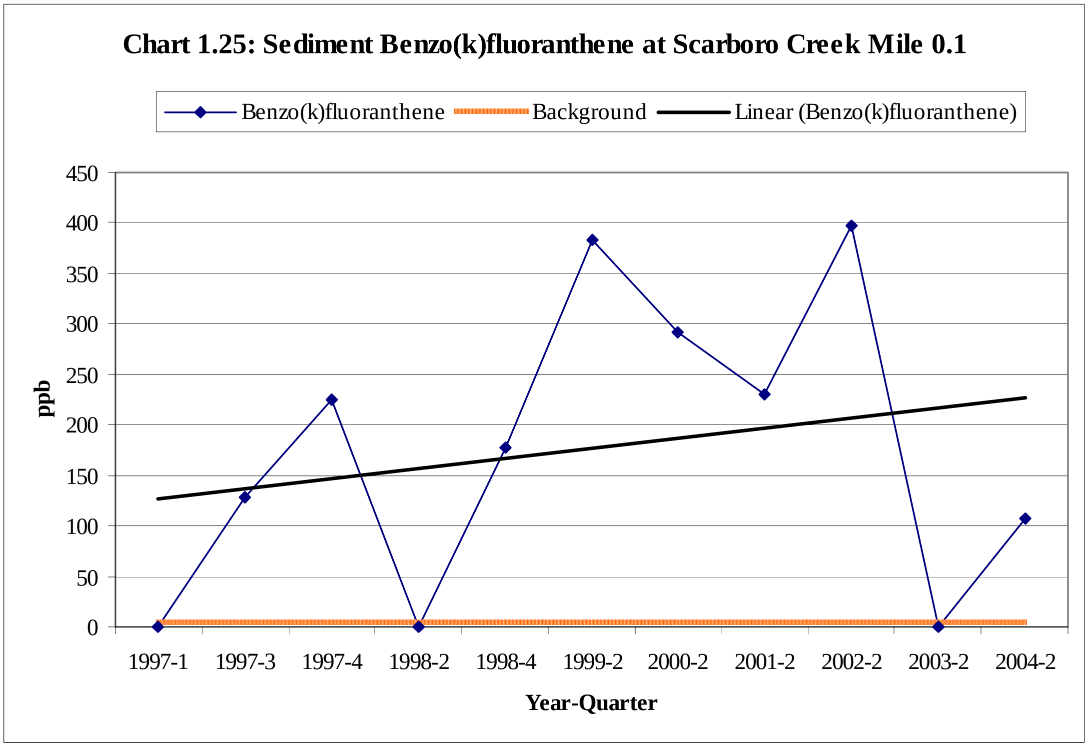
The PRG (total soil risk 1E-06) for Benzo(b)fluoranthene is 6350 µg/kg. The trend at Ernie's Creek is decreasing (Chart 1.22) while the trend at Scarboro Creek is increasing (Chart 1.23).



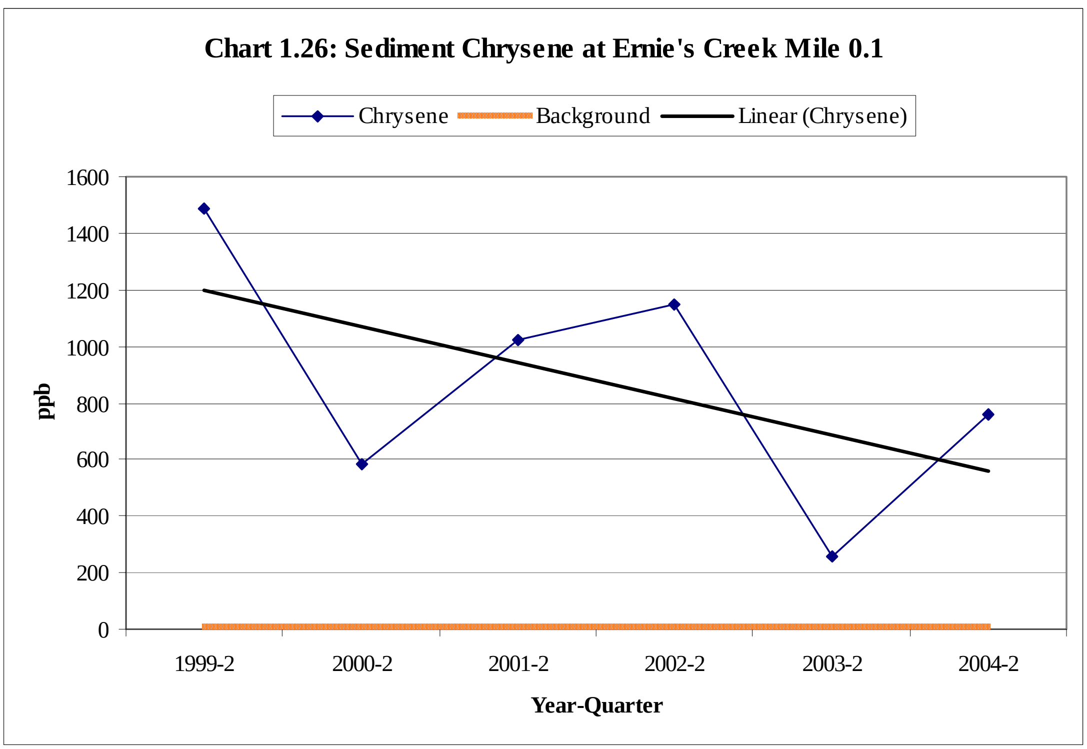


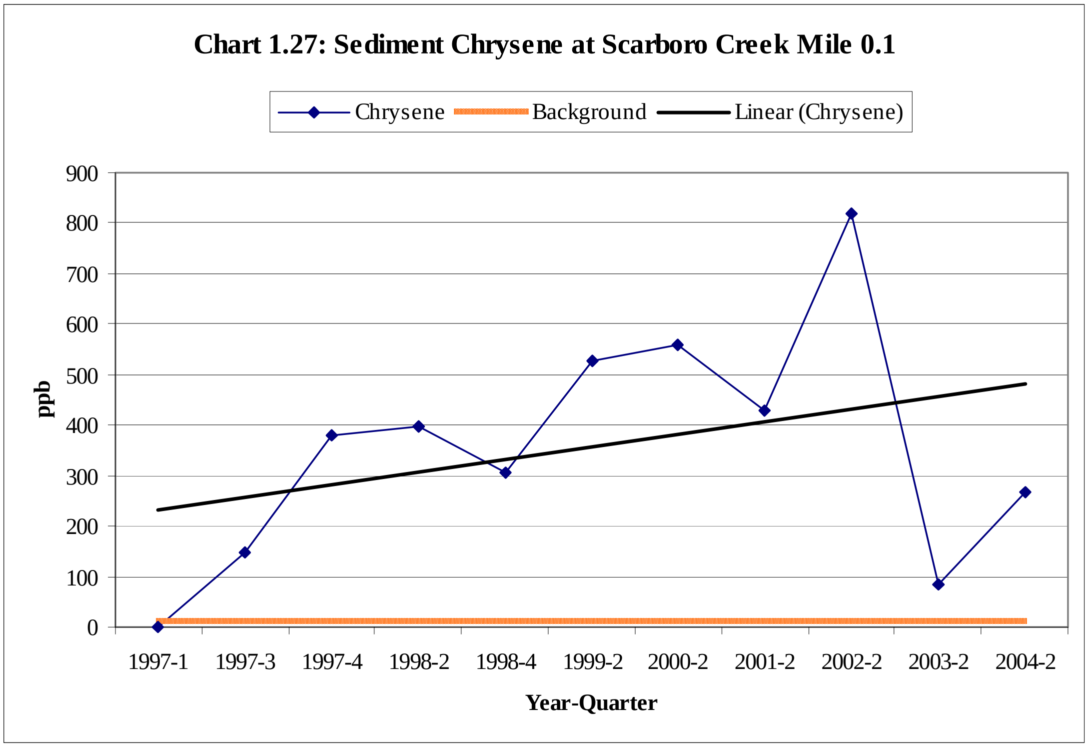
The PRG (total soil risk 1E-06) for Benzo(k)fluoranthene is 63,500 µg/kg. The trend at Ernie's Creek is decreasing (Chart 1.24) while the trend at Scarboro Creek is increasing (Chart 1.25).



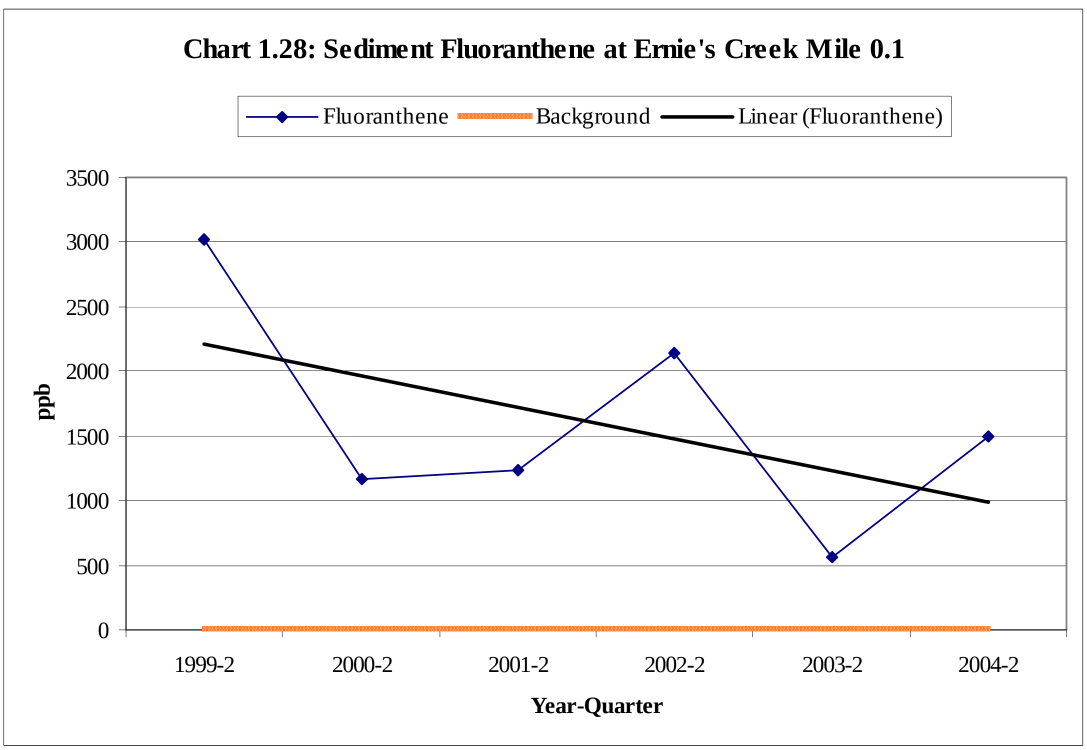


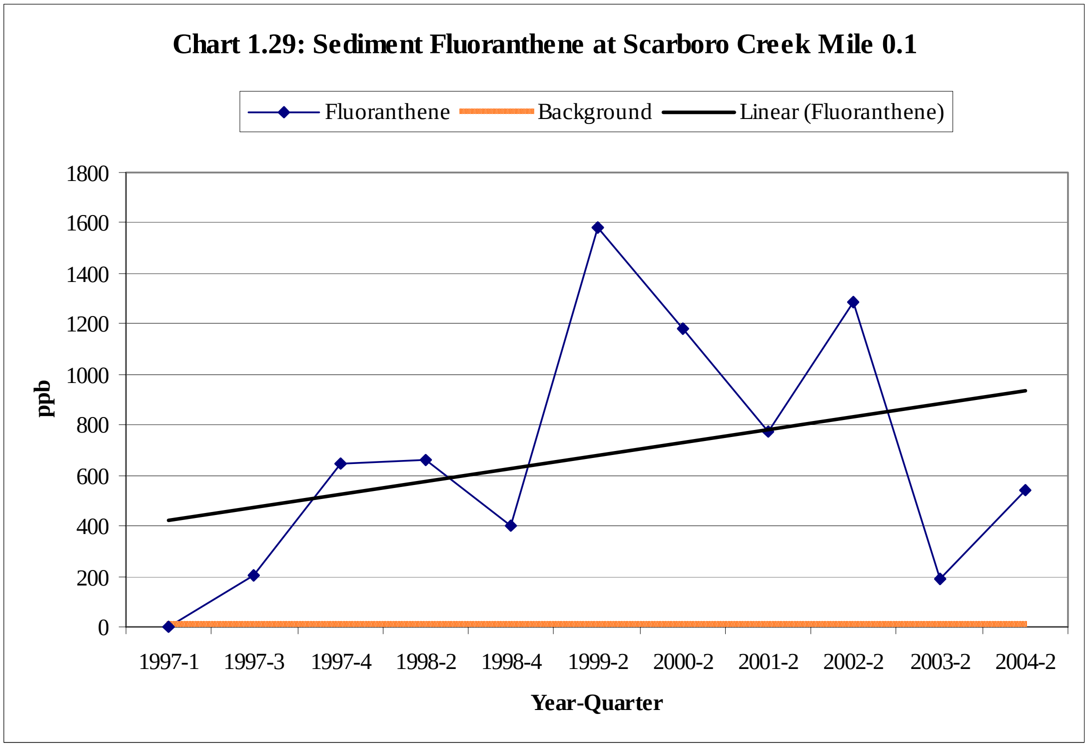
The PRG (total soil risk 1E-06) for Chrysene is 635,000 µg/kg. The trend at Ernie's Creek is decreasing (Chart 1.26) while the trend at Scarboro Creek is increasing (Chart 1.27).



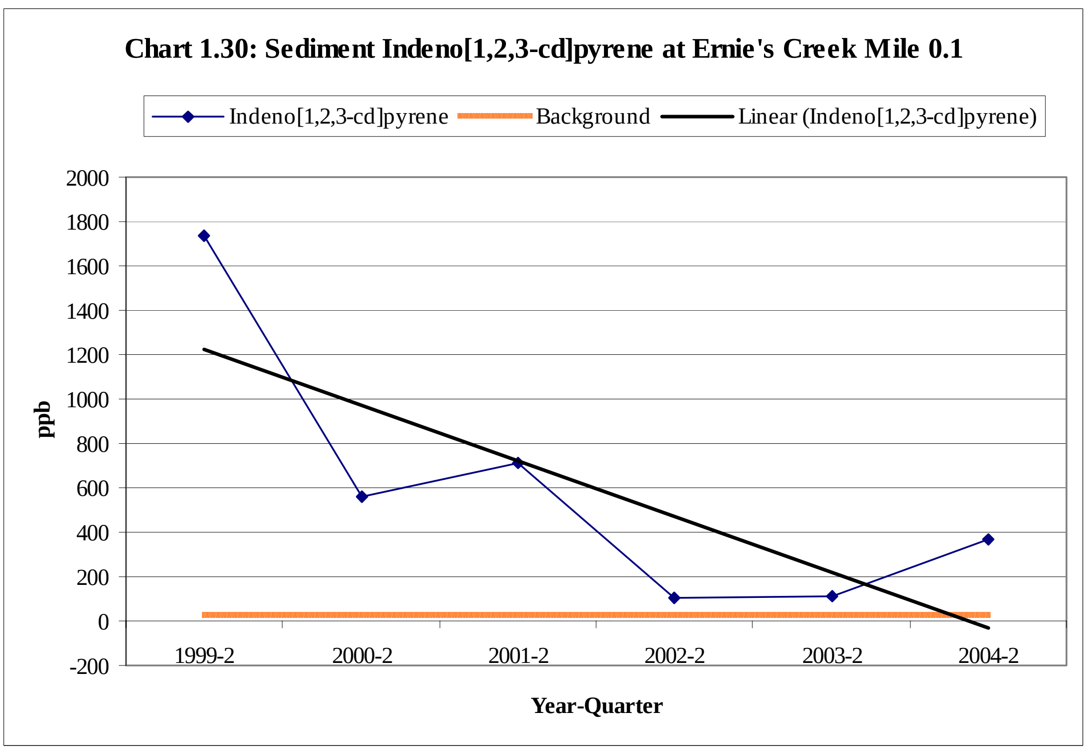


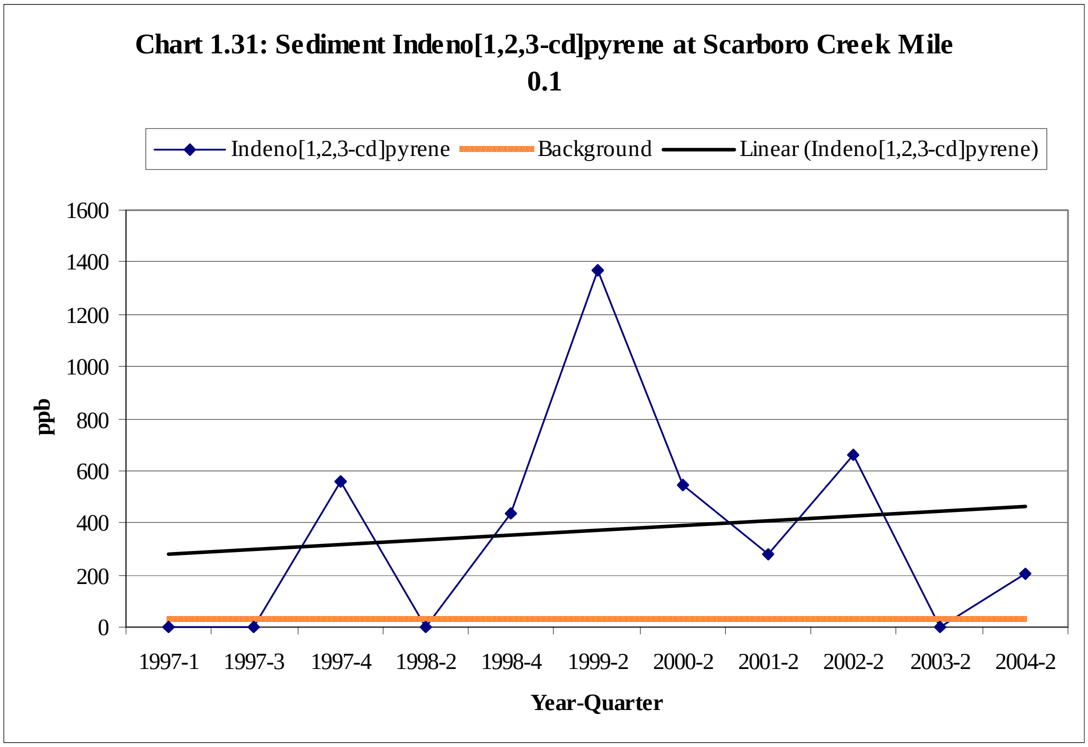
The PRG (total soil risk 1E-06) for Fluoranthene is 79,500,000 µg/kg. The trend at Ernie's Creek is decreasing (Chart 1.28) while the trend at Scarboro Creek is increasing (Chart 1.29).



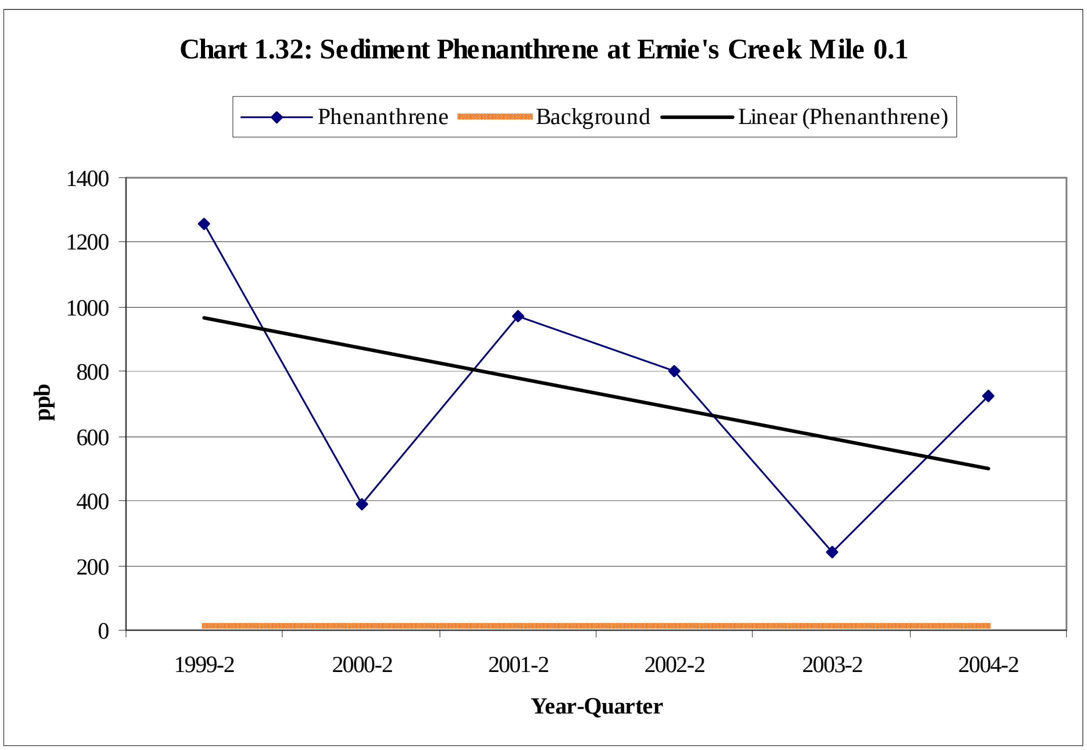


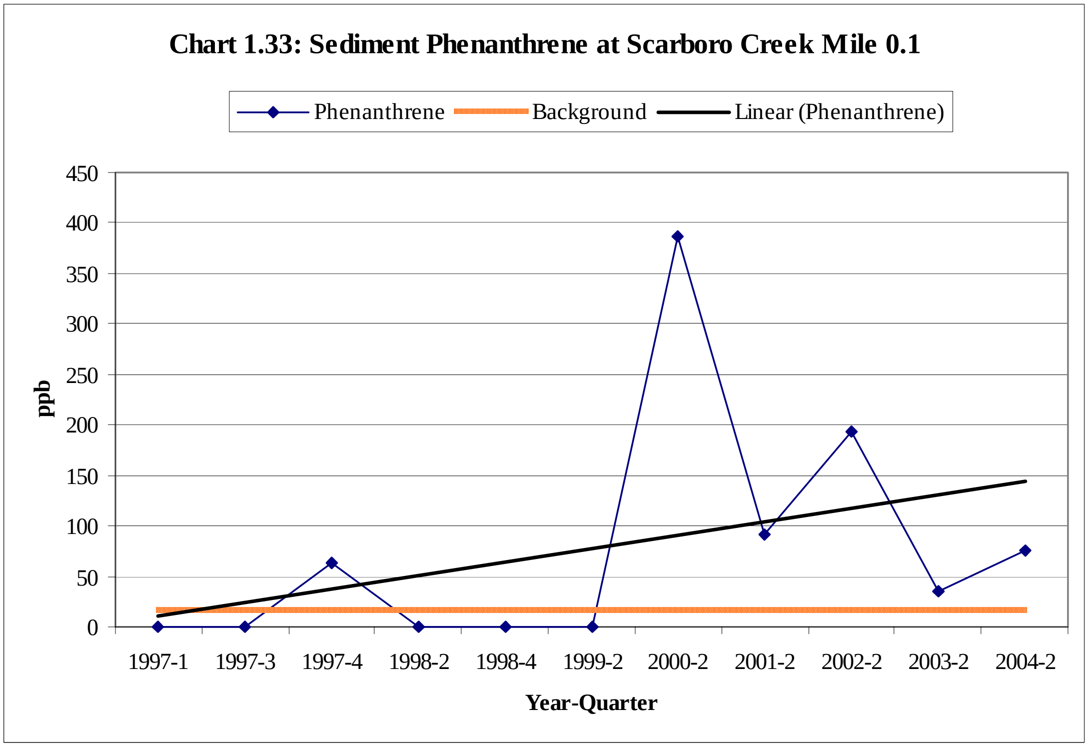
The PRG (total soil risk 1E-06) for Indeno[1,2,3-cd]pyrene is 6350 µg/kg. The trend at Ernie's Creek is decreasing (Chart 1.30) while the trend at Scarboro Creek is increasing (Chart 1.31).



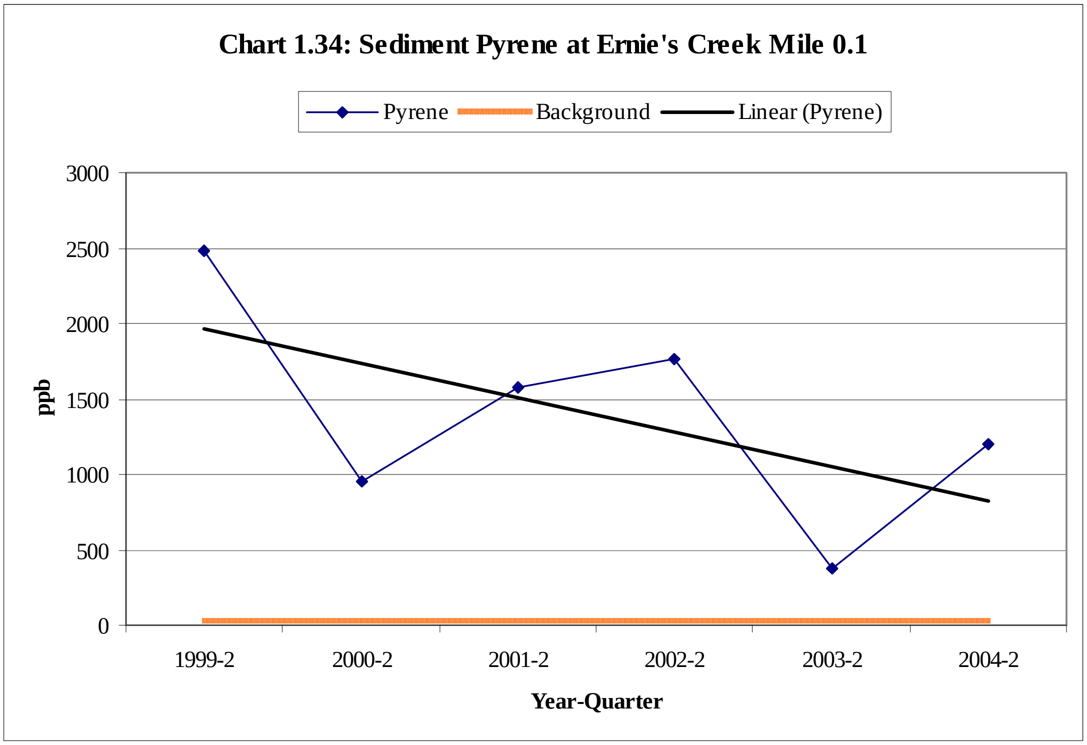


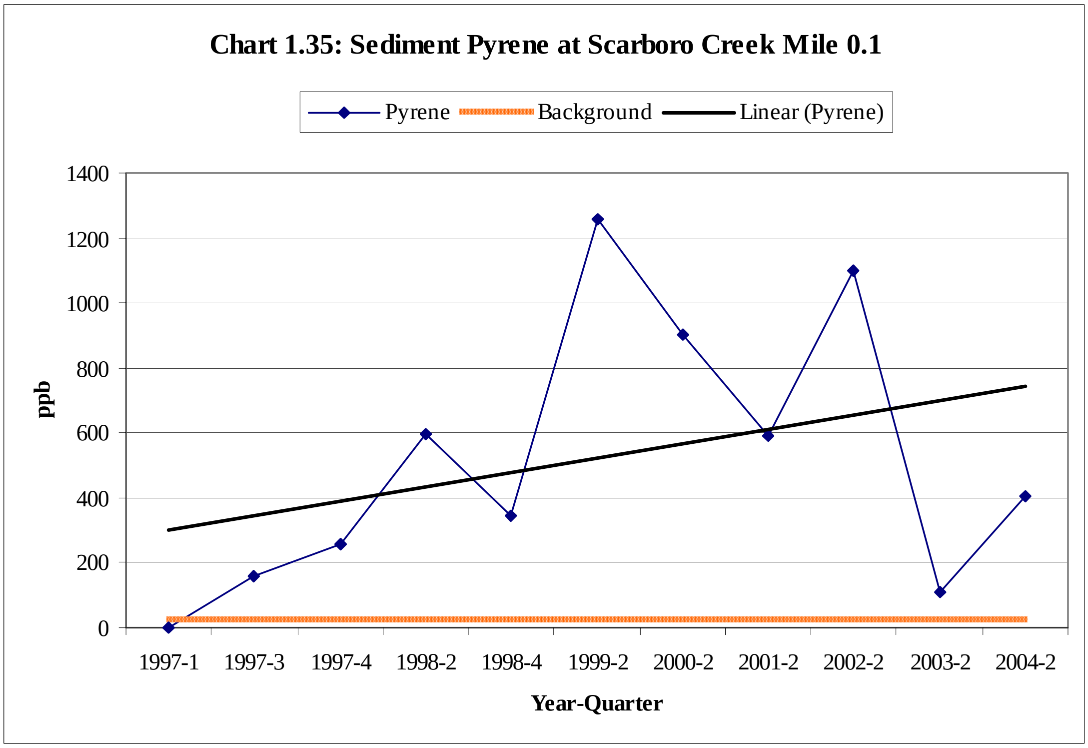
There is not a recreation PRG for Phenanthrene. The trend at Ernie's Creek is decreasing (Chart 1.32) while the trend at Scarboro Creek is increasing (Chart 1.33).





The PRG (total soil risk 1E-06) for Pyrene is 59,600,000 µg/kg. The trend at Ernie's Creek is decreasing (Chart 1.34) while the trend at Scarboro Creek is increasing (Chart 1.35).

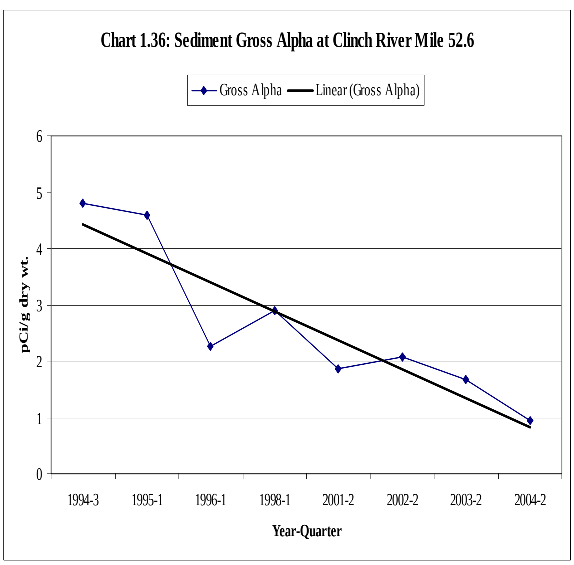


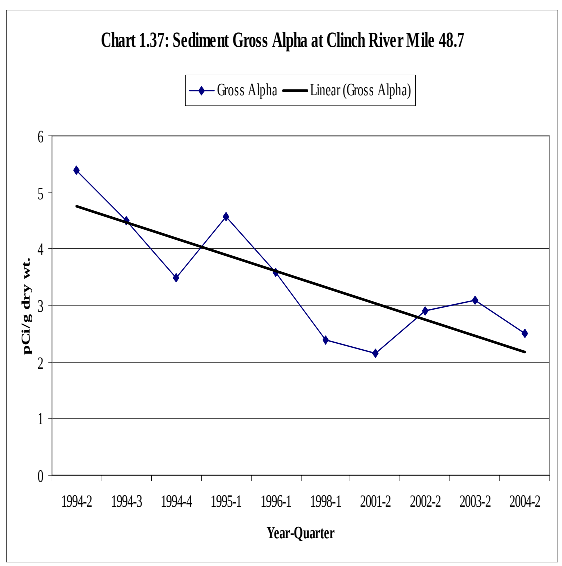


Raccoon Creek (site 18), East Fork Walker Branch (site 12), and Grassy Creek (site 20) also show PAHs above background levels but on a much smaller scale than Ernie's Creek and Scarboro Creek. For instance, values for PAHs at Raccoon Creek are roughly 10% of those for Ernie's Creek. East Fork Walker Branch and Grassy Creek PAH values are lower than those of Raccoon Creek. Again, there is no danger to human health as a result of the PAHs there.

Radiological Analyses

The radiological sediment data show no reason for concern; all parameters are well below DOE PRGs. Gross alpha values show a downward trend for all river and tributary sites (Charts 1.36 – 1.52).





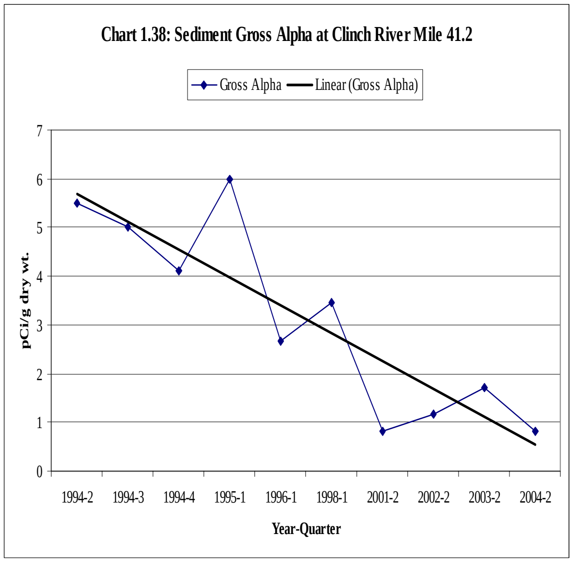


Chart 1.38: Sediment Gross Alpha at Clinch River Mile 41.2
Gross Alpha
Linear (Gross Alpha)
pCi/g dry wt.
Year-Quarter
1994-2
1994-3
1994-4
1995-1
1996-1
1998-1
2001-2
2002-2
2003-2
2004-2

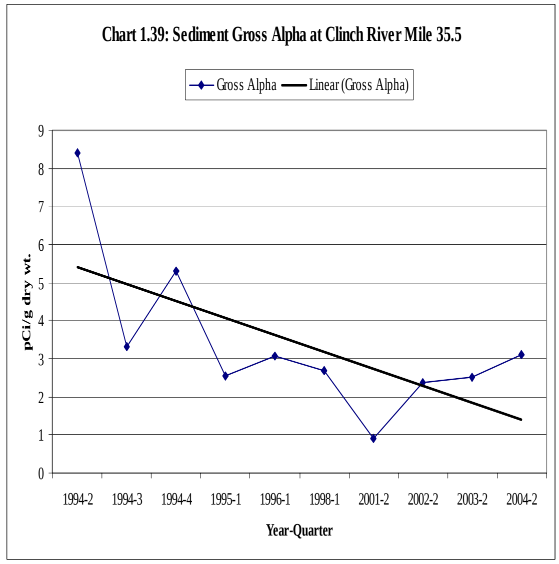


Chart 1.39: Sediment Gross Alpha at Clinch River Mile 35.5
Gross Alpha
Linear (Gross Alpha)
pCi/g dry wt.
Year-Quarter
1994-2
1994-3
1994-4
1995-1
1996-1
1998-1
2001-2
2002-2
2003-2
2004-2

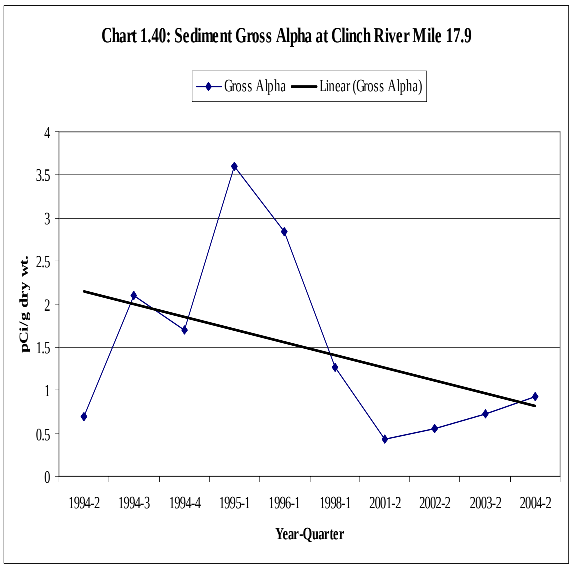


Chart 1.40: Sediment Gross Alpha at Clinch River Mile 17.9
Gross Alpha
Linear (Gross Alpha)
pCi/g dry wt.
Year-Quarter
1994-2
1994-3
1994-4
1995-1
1996-1
1998-1
2001-2
2002-2
2003-2
2004-2

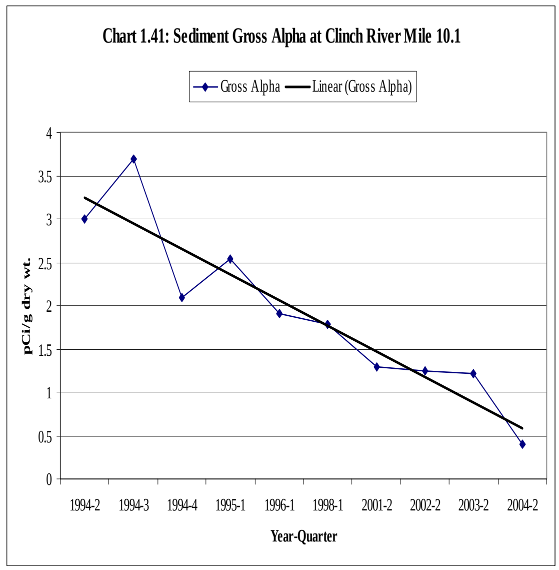


Chart 1.41: Sediment Gross Alpha at Clinch River Mile 10.1
Gross Alpha
Linear (Gross Alpha)
pCi/g dry wt.
Year-Quarter
1994-2
1994-3
1994-4
1995-1
1996-1
1998-1
2001-2
2002-2
2003-2
2004-2

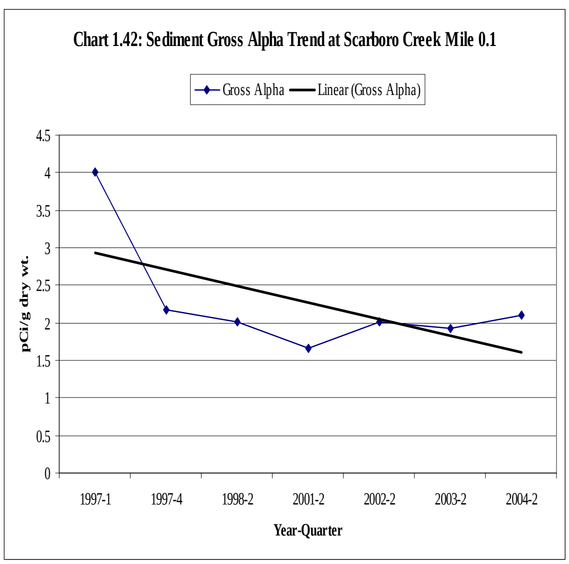


Chart 1.42: Sediment Gross Alpha Trend at Scarboro Creek Mile 0.1
Gross Alpha
Linear (Gross Alpha)
pCi/g dry wt.
Year-Quarter
1997-1
1997-4
1998-2
2001-2
2002-2
2003-2
2004-2

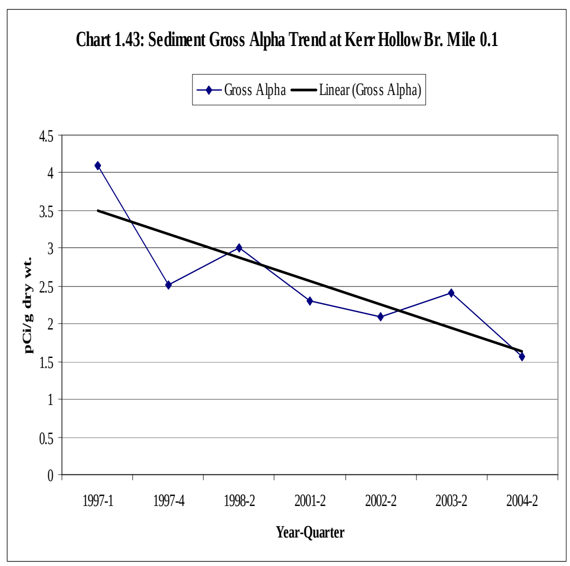


Chart 1.43: Sediment Gross Alpha Trend at Kerr Hollow Br. Mile 0.1
Gross Alpha
Linear (Gross Alpha)
pCi/g dry wt.
Year-Quarter
1997-1
1997-4
1998-2
2001-2
2002-2
2003-2
2004-2

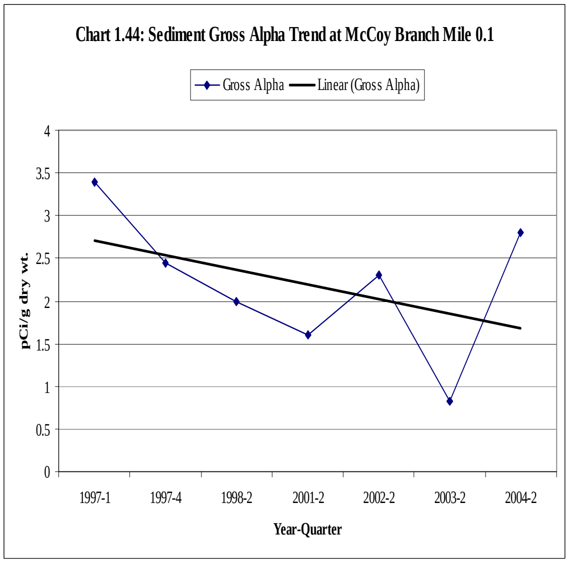


Chart 1.44: Sediment Gross Alpha Trend at McCoy Branch Mile 0.1
Gross Alpha
Linear (Gross Alpha)
pCi/g dry wt.
Year-Quarter
1997-1
1997-4
1998-2
2001-2
2002-2
2003-2
2004-2

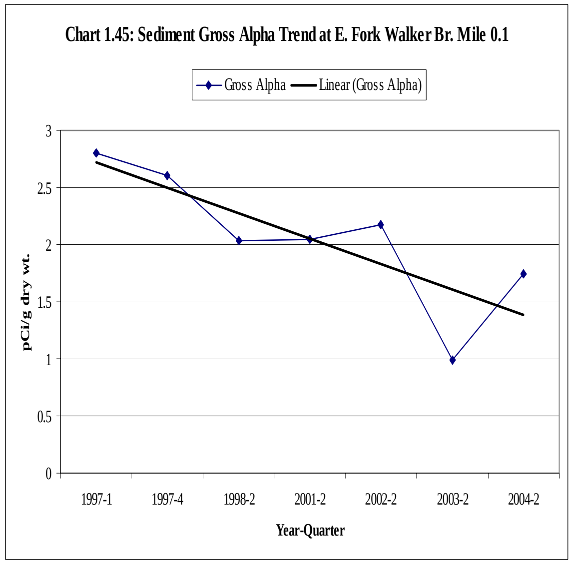


Chart 1.45: Sediment Gross Alpha Trend at E. Fork Walker Br. Mile 0.1
Gross Alpha
Linear (Gross Alpha)
pCi/g dry wt.
Year-Quarter
1997-1
1997-4
1998-2
2001-2
2002-2
2003-2
2004-2

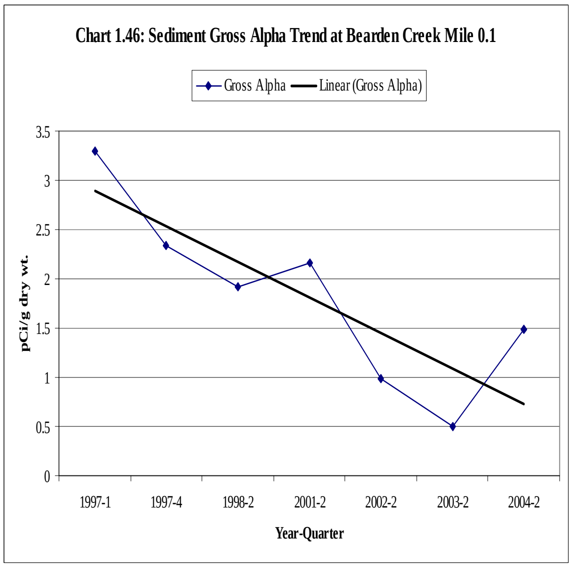


Chart 1.46: Sediment Gross Alpha Trend at Bearden Creek Mile 0.1
Gross Alpha
Linear (Gross Alpha)
pCi/g dry wt.
Year-Quarter
1997-1
1997-4
1998-2
2001-2
2002-2
2003-2
2004-2

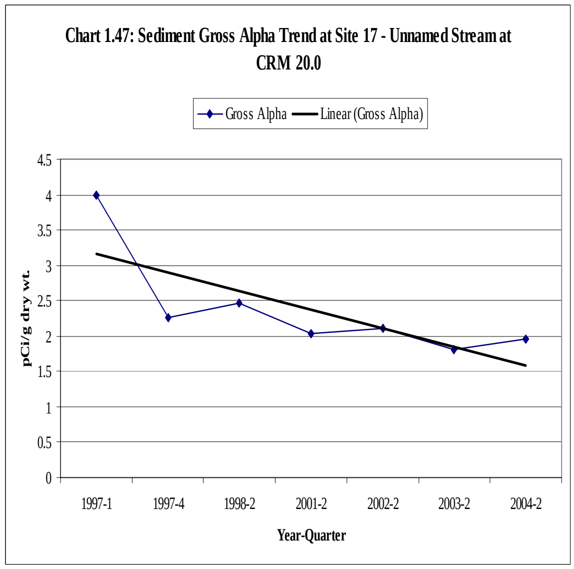


Chart 1.47: Sediment Gross Alpha Trend at Site 17 - Unnamed Stream at CRM 20.0
Gross Alpha
Linear (Gross Alpha)
pCi/g dry wt.
Year-Quarter
1997-1
1997-4
1998-2
2001-2
2002-2
2003-2
2004-2

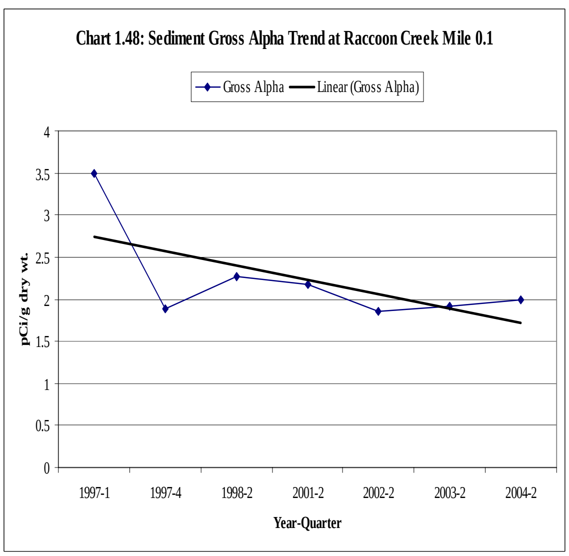


Chart 1.48: Sediment Gross Alpha Trend at Raccoon Creek Mile 0.1
Gross Alpha
Linear (Gross Alpha)
pCi/g dry wt.
Year-Quarter
1997-1
1997-4
1998-2
2001-2
2002-2
2003-2
2004-2

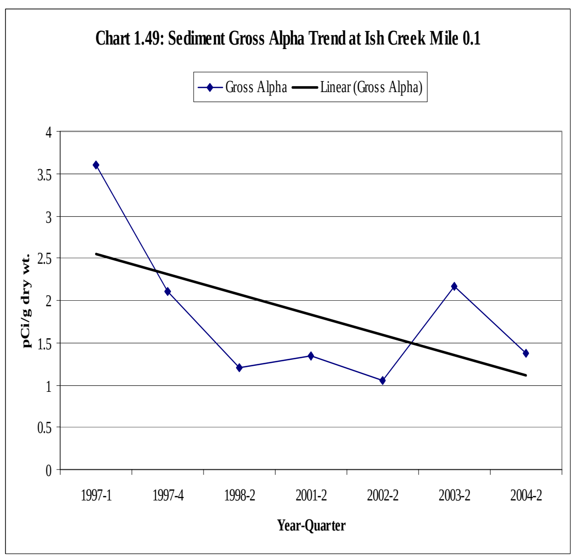
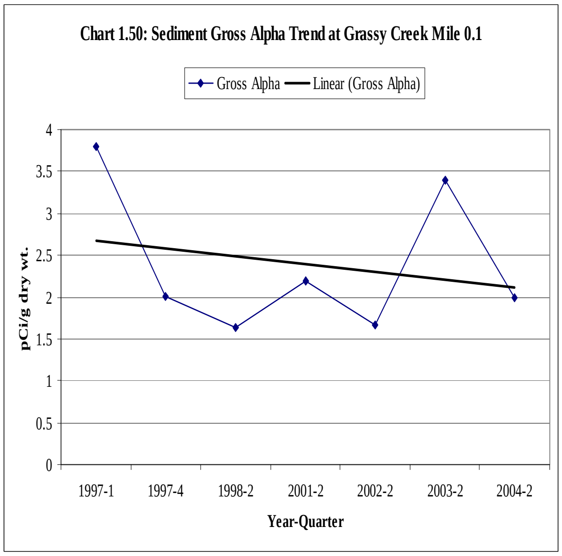
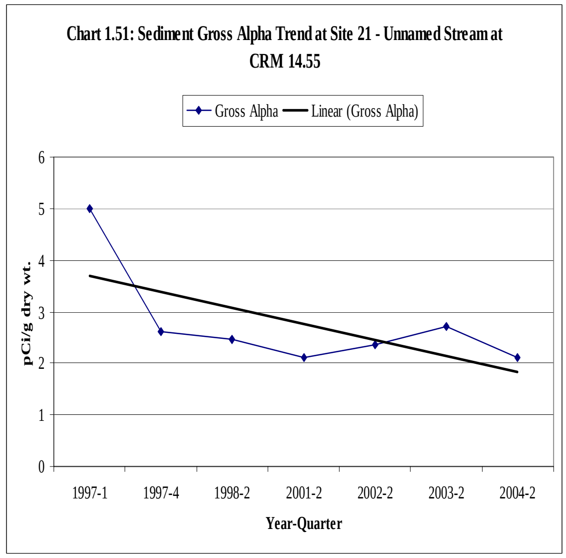
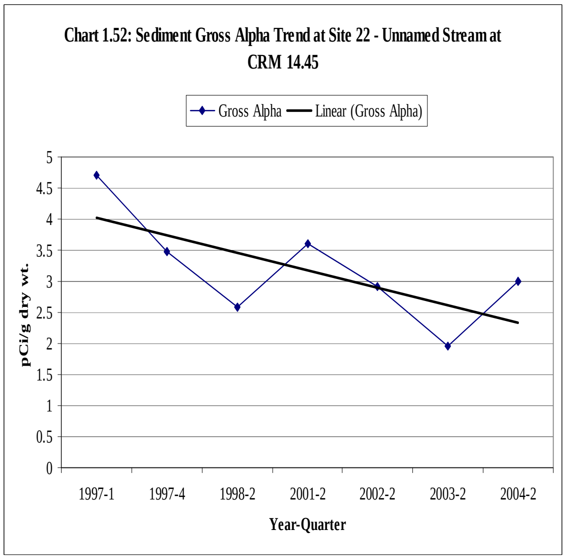


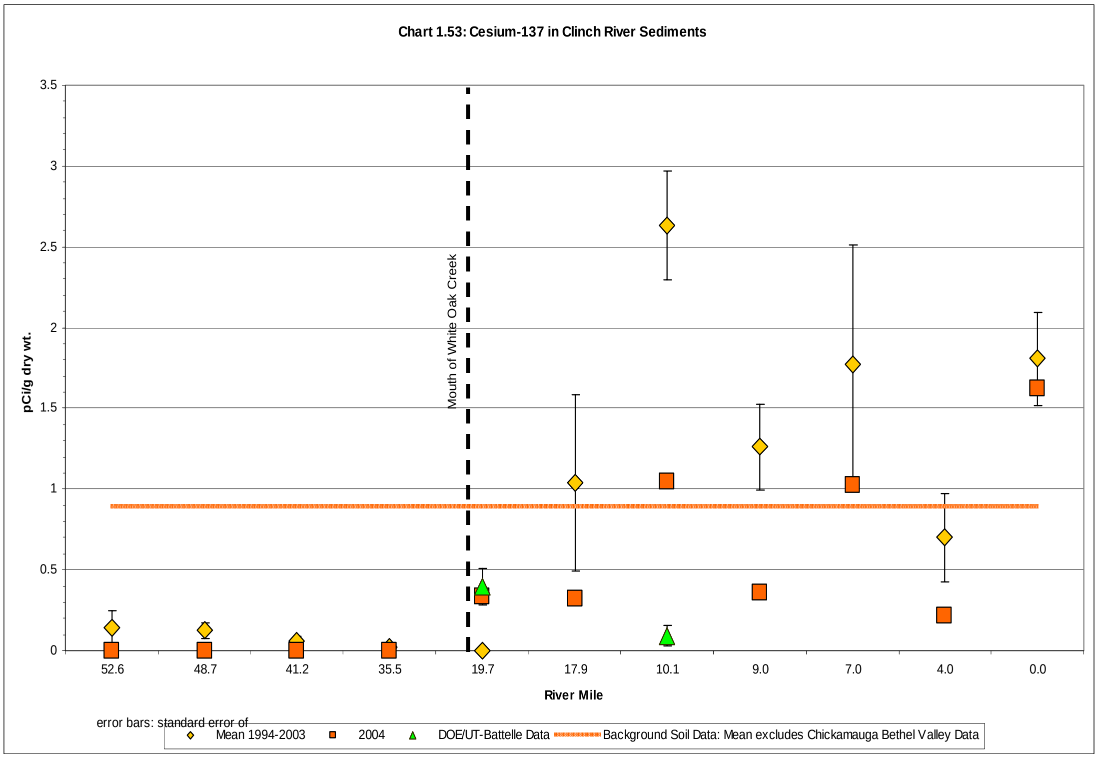
Chart 1.49: Sediment Gross Alpha Trend at Ish Creek Mile 0.1
Gross Alpha
Linear (Gross Alpha)
pCi/g dry wt.
Year-Quarter
1997-1
1997-4
1998-2
2001-2
2002-2
2003-2
2004-2

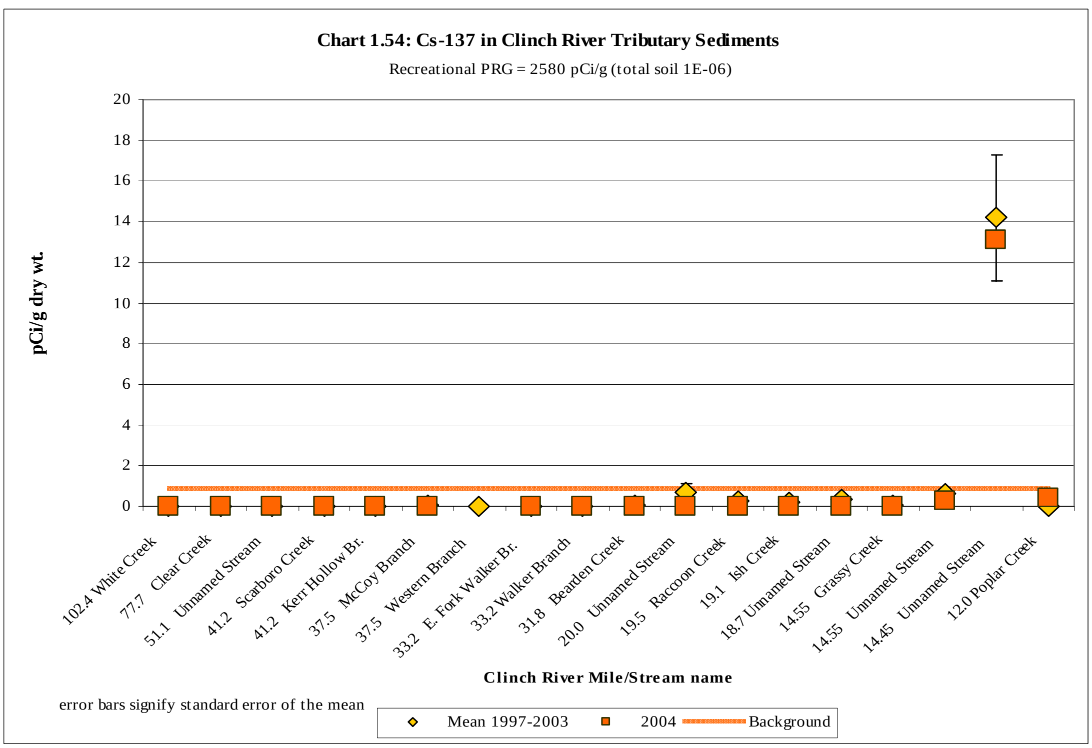




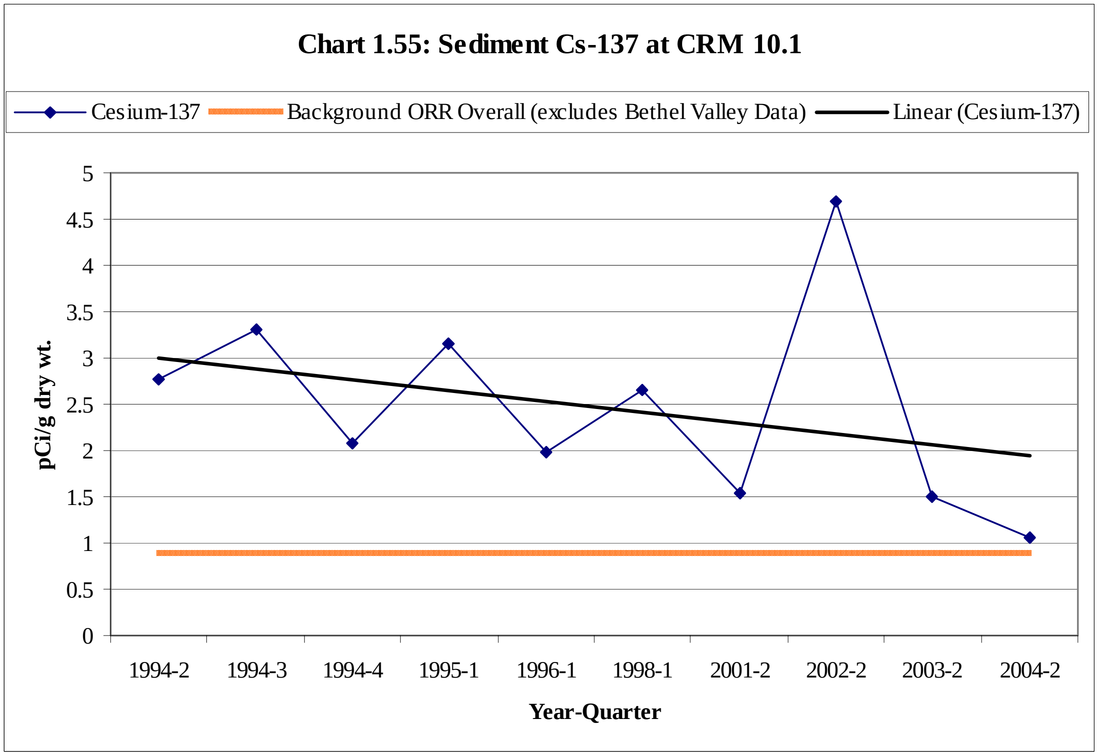


In the Clinch River, Cs-137 levels are typically higher in samples taken downstream of the mouth of White Oak Creek than those taken upstream (see Chart 1.53). The recreational PRG for Cs-137 is 2580 pCi/g (total soil 1E-06). Site 22 (CRM 14.45) has shown significantly higher levels of Cs-137 than all of the other sites. The mean for Cs-137 at site 22 (based on 6 samples taken between 1997 and 2003) is 14.18 pCi/g (standard error 3.08). The value for 2004 was 13.09 ± 0.20 pCi/g. This stream runs through the K-1515C lagoon that was once used to receive backwash material from filters at the ETTP Water Treatment Plant. It is believed that these water filters concentrated the Cs-137 from suspended river sediments. The K-1515C lagoon is no longer used for the purpose of catching filter backwash material.





Sediment at site 5 (CRM 10.1) has Cs-137 levels above background as a result of contamination by White Oak Creek. Most of the river sampling sites below Jones Island show Cs-137 above background but site 5 has the highest levels (Chart 1.53). Note the DOE sediment sampling data comparisons at CRM 19.7 (Jones Island) and at site 5 (Brashear's Island). The data at Jones Island is similar to TDEC DOE-O's data but the data for site 5 (CRM 10.1) is much lower than the TDEC data. This difference may be in the different sampling methods used: DOE/UT-Battelle takes sediment samples from the bank of the river whereas TDEC takes samples with a petite ponar dredge from the river channel. The trend for Cs-137 at site 5 is downward (Chart 1.55). Other sites downstream of Jones Island appear to be decreasing as well but there is not enough data at the present time to be sure.



Conclusion

Sediment data from 2004 samplings show no levels of contamination that exceed DOE Preliminary Remediation Goals (PRGs) for recreation and based on these criteria do not pose a threat to human health. If in the future, these sediments are to be used for agricultural and/or other purposes, analysis may be performed to determine the suitability for these new purposes. Mercury levels in the samples taken in the Clinch River below the confluence of Poplar Creek increase as one goes downstream. Although the levels of mercury are well below the recreational PRG, they are higher than all of the other sediment sampling sites. Site 22 (CRM 14.45) has shown considerably higher levels of Cs-137 than all of the other sites. This is believed to be due to the effect of concentrating suspended Cs-137-contaminated sediment particles in river water by filters at the ETTP Water Treatment Plant and disposing of the filter backwash material in the K-1515C lagoon. This lagoon is no longer used for this purpose. Cs-137 is found at levels that are above background at most of the sites below the mouth of White Oak Creek. The levels are very low and do not pose a threat to recreation or human health. This contamination appears to be decreasing over time as a result of the radioactive decay of the Cs-137.

Table 1.1 Sample Locations for Sediment in 2004:

Site	Location	Clinch River Mile
2	Clinch River Mile 52.6	52.6
3	Melton Hill Park	35.5
4	Grubb Islands	17.9
5	Brashear's Island	10.1
6	Bull Run Steam Plant	48.7
7	Clinch River Mile 41.2	41.2
8	Scarboro Creek	41.2
9	Kerr Hollow Branch	41.2
10	McCoy Branch	37.5
11	Western Branch	37.5
12	East Fork Walker Branch	33.2
13	Bearden Creek	31.8
14	Unnamed Stream	27.0
15	Unnamed Stream	26.6
16	Unnamed Stream	23.0
17	Unnamed Stream	20.0
18	Raccoon Creek	19.5
19	Ish Creek	19.1
20	Grassy Creek	14.55
21	Unnamed Stream	14.55
22	Unnamed Stream	14.45
23	Ernie's Creek	51.1
24	White Creek	102.4
25	Clear Creek	77.7
26	Clinch River Mile 9.0	9.0
27	Clinch River Mile 7.0	7.0
28	Clinch River Mile 4.0	4.0
29	Clinch River Mouth	0.0
30	Tennessee River Mile 569	n.a.
31	Tennessee River Mile 567	n.a.
32	Jones Island	19.7
33	Poplar Creek	12.0
34	Walker Branch	33.2
35	Unnamed Stream	18.7

Figure 1.1: Sediment Monitoring Sites

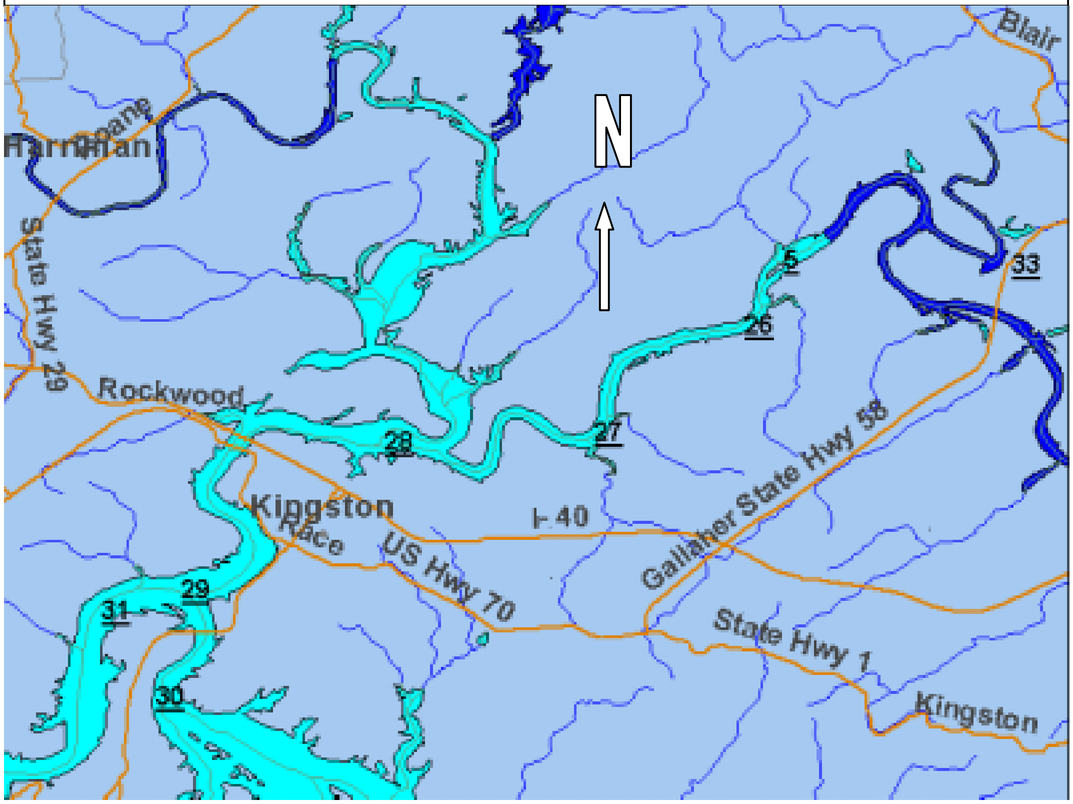


Figure1.2: Sediment Monitoring Sites

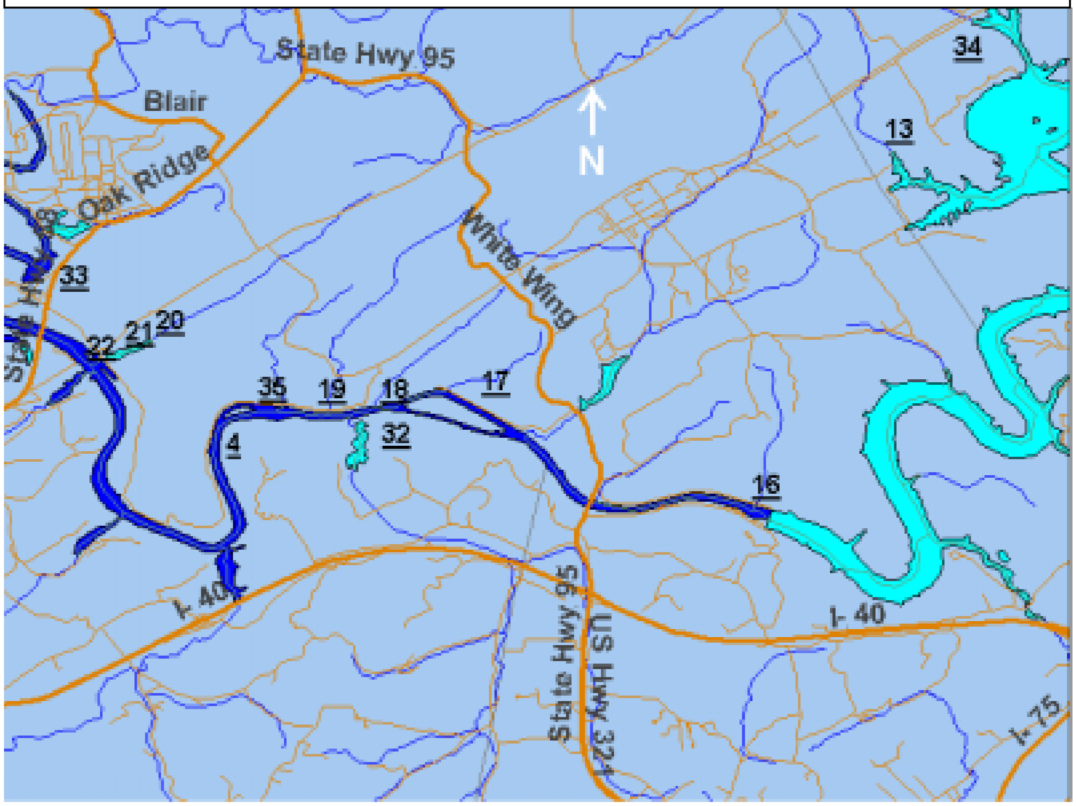


Figure 1.3: Sediment Monitoring Sites

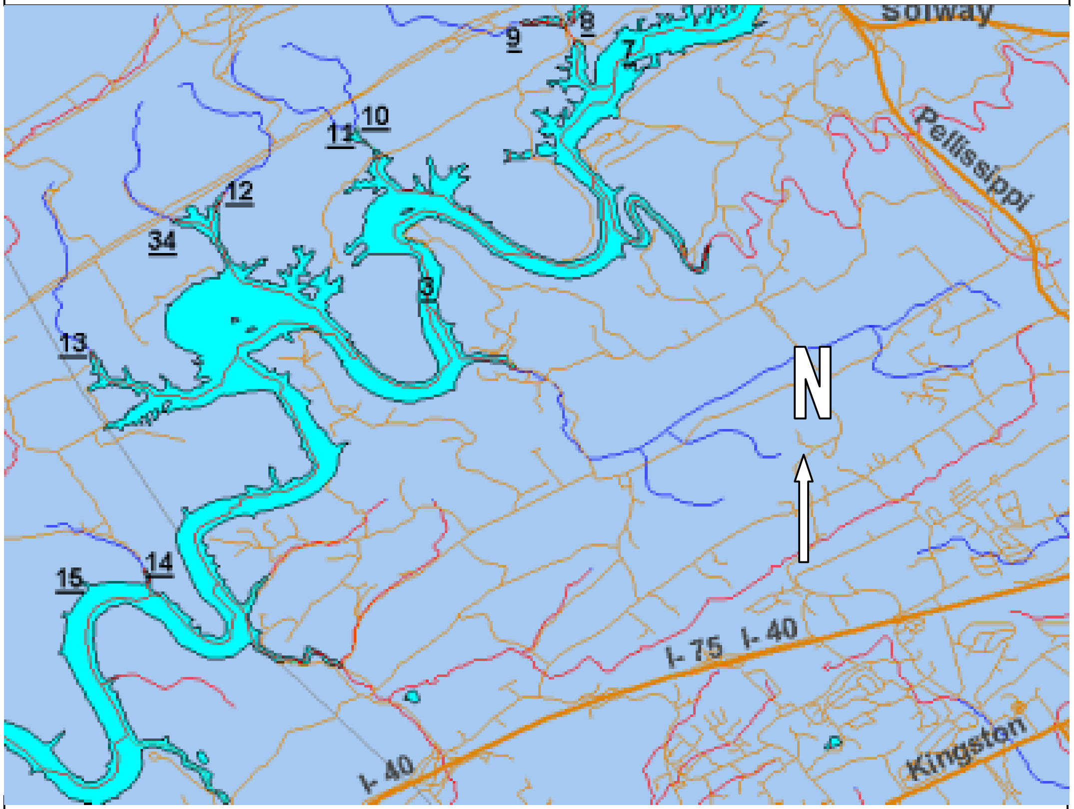


Figure 1.4: Sediment Monitoring Sites

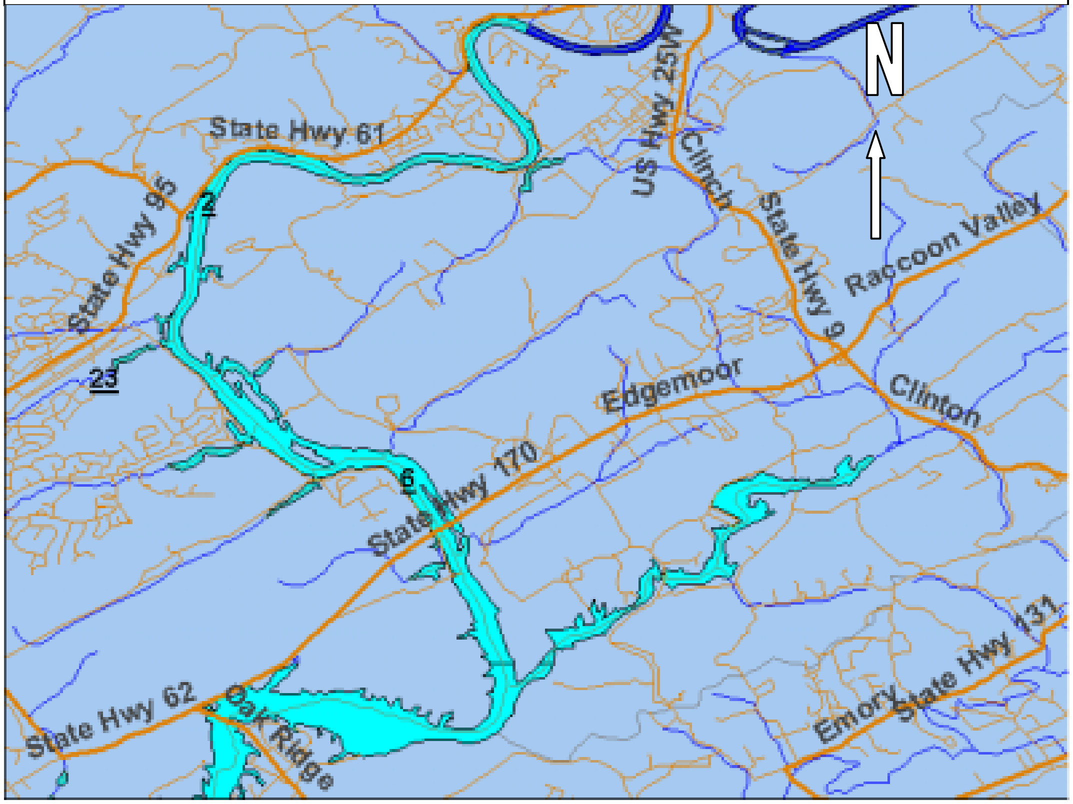


Figure 1.5: Sediment Monitoring Sites

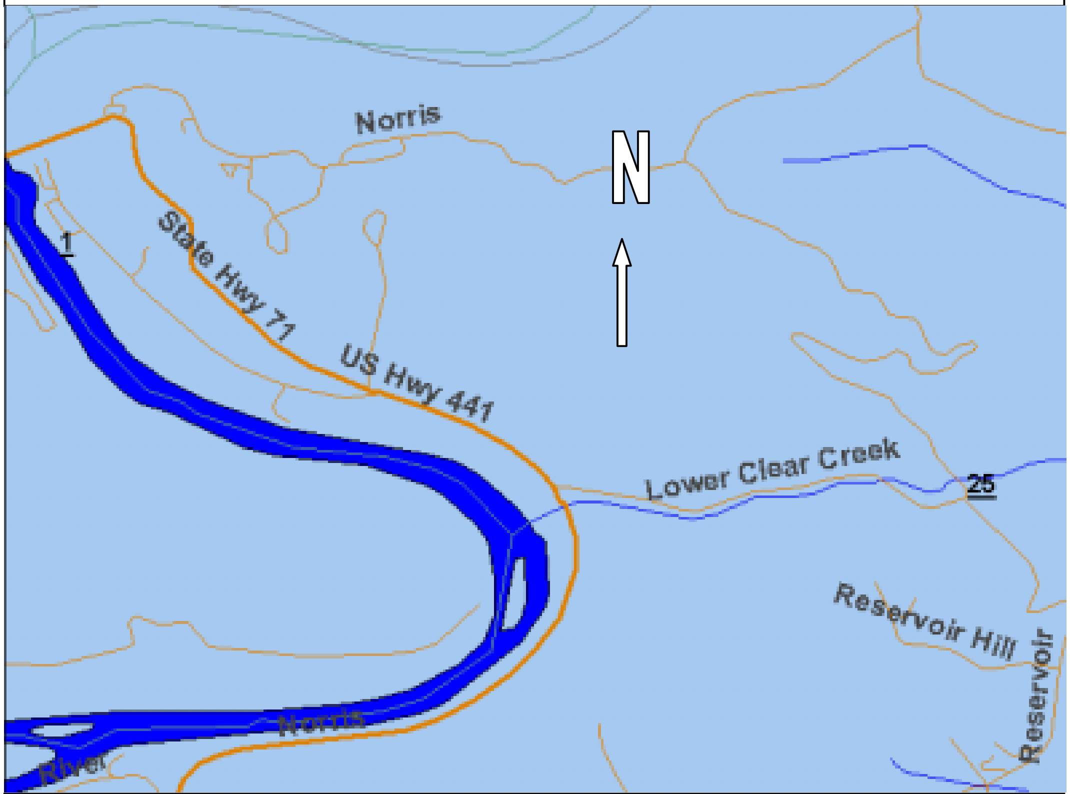
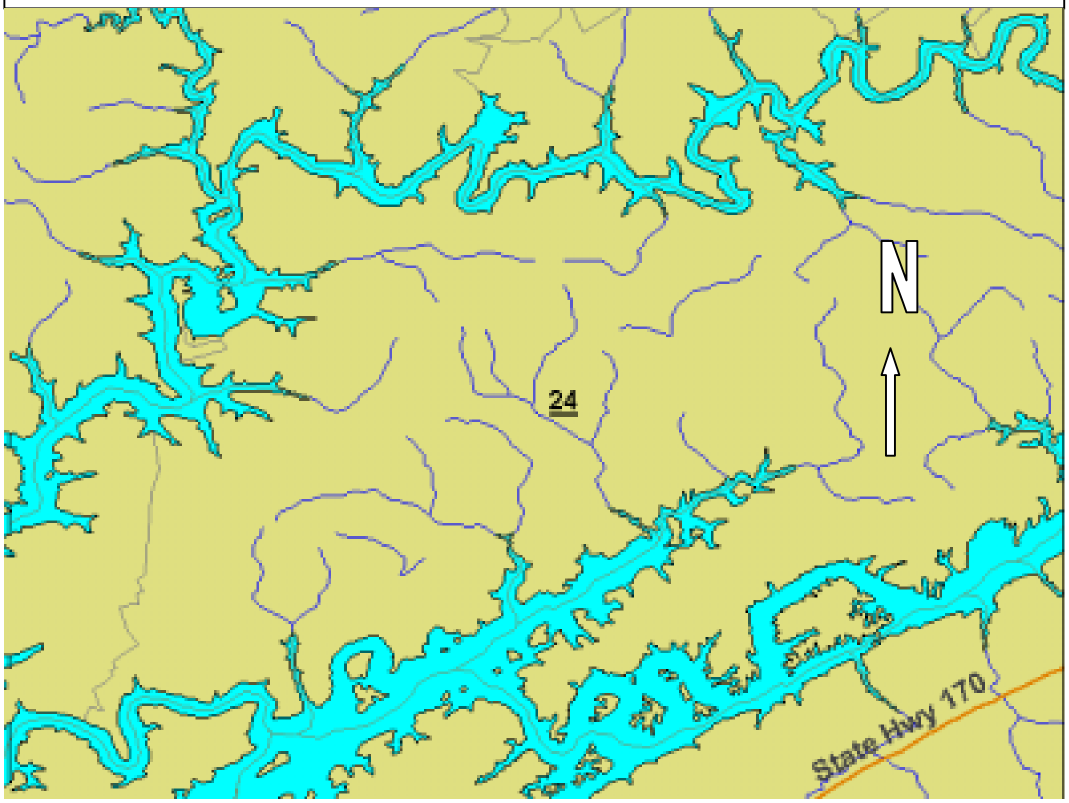


Figure 1.6: Sediment Monitoring Sites



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DOE (Department of Energy) 1993b. *Final Report on the Background Soil Characterization Project at the Oak Ridge Reservation, Oak Ridge, Tennessee*, DOE/OR/01-1175/V2, Oak Ridge, Tennessee.

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TDH (Tennessee Department of Health Laboratory Services) 1999. *Standard Operating Procedures.* Nashville, Tennessee.

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CHAPTER 6 SURFACE WATER MONITORING

Ambient Surface Water Monitoring Program

Principle Author: John G. Peryam

Abstract

The DOE Oversight Division conducted surface water sampling at 26 sites on the Clinch River and its tributaries in 2004. The samples were analyzed for certain metals, nutrients, and physical parameters.

Introduction

The Tennessee Department of Environment and Conservation's DOE Oversight Division (the division) conducts an ambient surface water monitoring program that monitors 26 sites semi-annually for the purpose of detecting possible contamination from DOE sites. There are eight sites on the Clinch River, two of which are background sites and are not affected by Oak Ridge Reservation operations. Tributaries of the Clinch River make up the other 18 sampling sites. Two of the tributary sites are located upstream of the Oak Ridge Reservation and serve as background data sites.

The Clinch River, being large and subject to dilution, is not expected to have high concentrations of pollutants in surface water grab samples. However, the sampling data do set up a baseline for comparison to previous sampling events. In the case of an unplanned release or an accident, the sampling data may help to reflect the amount and extent of pollution.

The sampling sites were sampled twice during 2004, once in May/June and in November. Samples were analyzed for E. coli, Enterococcus, ammonia, COD, dissolved residue, NO3 & NO2 nitrogen, suspended residue, total hardness, total kjeldahl nitrogen, total phosphate, arsenic, cadmium, copper, iron, lead, manganese, mercury, chromium, and zinc.

Methods and Materials

Surface water samples were taken during June/July and October using the methods described in the 2004 Ambient Surface Water Monitoring Plan. The Tennessee State Department of Health (TDH) Laboratories processed the samples, according to EPA approved methods.

Results and Discussion

Surface water quality in the Clinch River and tributaries sampled is good. Copper is slightly higher at Clinch River Mile (CRM) 35.5 (site 3) than at the other river sites (Chart 1.1). The mean of the copper data at this site is 11.6 µg/L and the calculated Tennessee Water Quality Criteria (TWQC) (Criterion Continuous Concentration) for Fish & Aquatic Life is 11.3 µg/L. The high mean is due to one sample (229 µg/L) taken in the second quarter of 1995. The trend for copper at site 3 is decreasing (Chart 1.2).

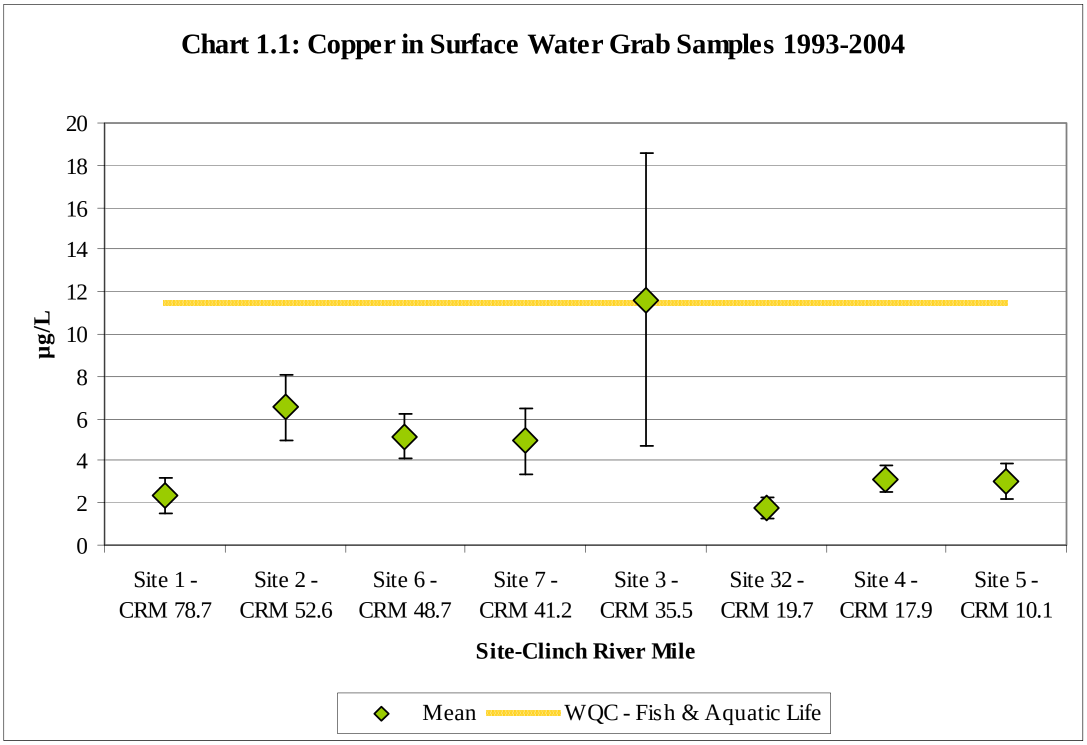


Chart 1.1: Copper in Surface Water Grab Samples 1993-2004
20
18
16
14
12
10
8
6
4
2
0
µg/L
Site 1 - CRM 78.7
Site 2 - CRM 52.6
Site 6 - CRM 48.7
Site 7 - CRM 41.2
Site 3 - CRM 35.5
Site 32 - CRM 19.7
Site 4 - CRM 17.9
Site 5 - CRM 10.1
Site-Clinch River Mile
Mean
WQC - Fish & Aquatic Life

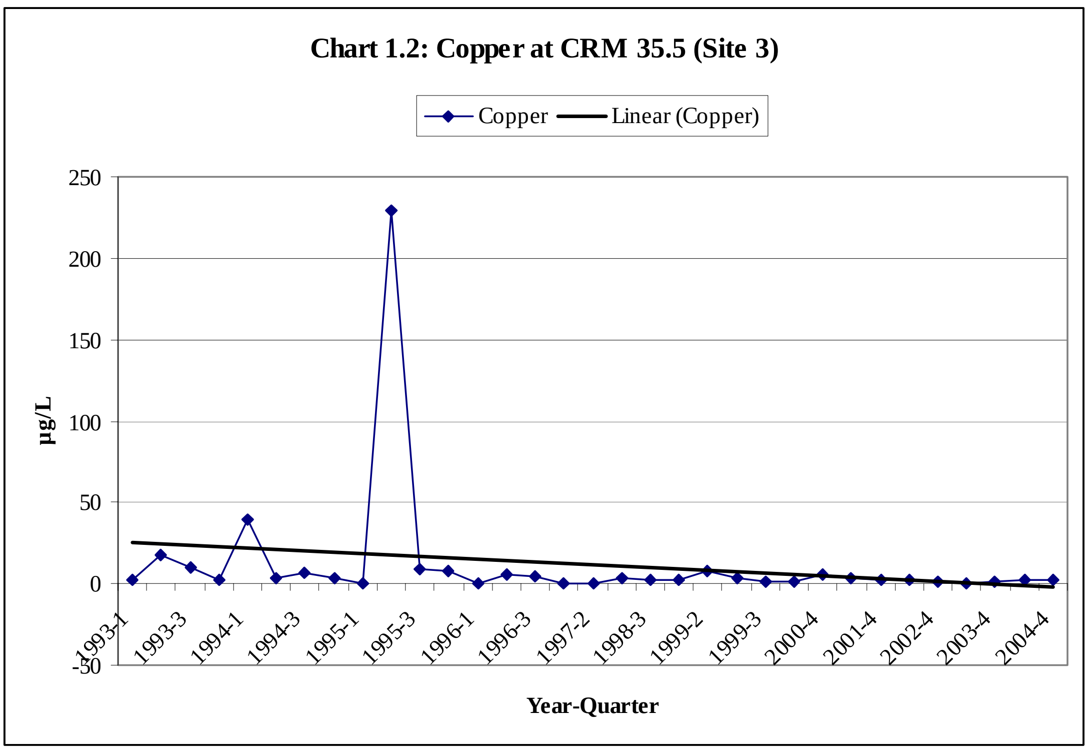
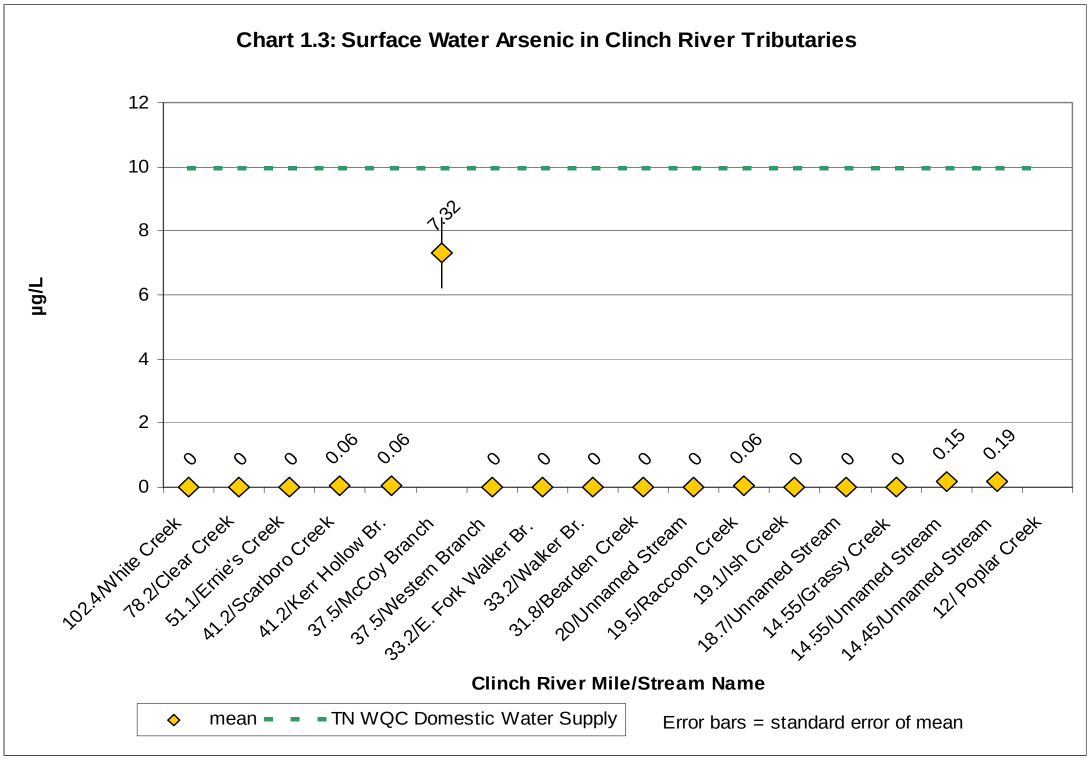
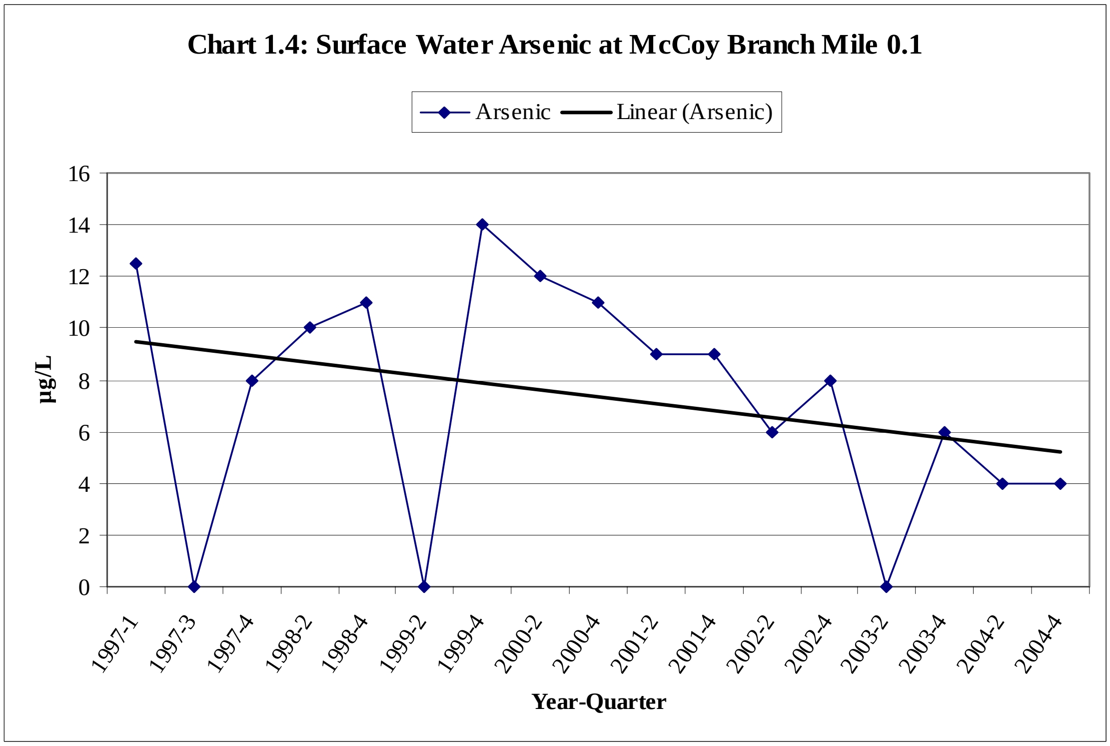


Chart 1.2: Copper at CRM 35.5 (Site 3)
Copper
Linear (Copper)
250
200
150
100
50
0
-50
µg/L
1993-1
1993-3
1994-1
1994-3
1995-1
1995-3
1996-1
1996-3
1997-2
1998-3
1999-2
1999-3
2000-4
2001-4
2002-4
2003-4
2004-4
Year-Quarter

Arsenic is slightly elevated in McCoy Branch (site 10) but is well below TWQC (Chart 1.3). This arsenic is from naturally arsenic-rich geological material at the headwaters of the stream on the south side of Chestnut Ridge. There also may be a contribution from the remediated Filled Coal Ash Pond. Arsenic is rarely found in river samples or in the other tributary sites (Chart 1.3). The arsenic levels at McCoy Branch appear to be decreasing over time (Chart 1.4).





Conclusion
The water quality of the Clinch River and the tributaries sampled is good. Lab results indicate that there is no threat to human health or wildlife.

Table 1.1 Sample Locations:

Site	Location	Clinch River Mile	Map
1	Downstream of Norris Dam	78.7	Figure 1.5
2	Clinch River Mile 52.6	52.6	Figure 1.4
3	Melton Hill Park	35.5	Figure 1.3
4	Grubb Islands	17.9	Figure 1.2
5	Brashear Island	10.1	Figure 1.1
6	Bull Run Steam Plant	48.7	Figure 1.4
7	Clinch River Mile 41.2	41.2	Figure 1.3
8	Scarboro Creek	41.2	Figure 1.3
9	Kerr Hollow Branch	41.2	Figure 1.3
10	McCoy Branch	37.5	Figure 1.3
11	Western Branch	37.5	Figure 1.3
12	East Fork of Walker Branch	33.2	Figure 1.3
13	Bearden Creek	31.8	Figure 1.3
17	Unnamed Stream	20.0	Figure 1.2
18	Raccoon Creek	19.5	Figure 1.2
19	Ish Creek	19.1	Figure 1.2
20	Grassy Creek	14.55	Figure 1.2
21	Unnamed Stream	14.55	Figure 1.2
22	Unnamed Stream	14.45	Figure 1.2
23	Ernie's Creek	51.1	Figure 1.4
24	White Creek	102.4	Figure 1.6
25	Clear Creek	77.7	Figure 1.5
32	Jones Island	19.7	Figure 1.2
33	Poplar Creek	12.0	Figure 1.2
34	Walker Branch	33.2	Figure 1.3
35	Unnamed Stream	18.7	Figure 1.2

Sampling Sites

Site 1 – Downstream of Norris Dam: Samples are taken at Clinch River Mile (CRM) 78.7. The coordinates are approximately 36º 13' 11" N latitude and 84º 05' 20" W longitude. See Figure 1.5.

Site 2 - Anderson County Water Treatment Plant: Samples are taken at CRM 52.6. See Figure 1.4.

Site 3 - Melton Hill Park: Samples are taken at CRM 35.5. See Figure 1.3.

Site 4 - Grubb Islands: Samples are taken at CRM 17.9. The coordinates are approximately 35º 53' 52" N latitude and 84º 22' 24" W longitude. See Figure 1.2.

Site 5 - Brashear Island: Samples are taken at CRM 10.1. The coordinates are approximately 35º 55' 13" N latitude and 84º 26' 02" W longitude. See Figure 1.1.

Site 6 - Bull Run Steam Plant: Samples are taken at CRM 48.7. The coordinates are approximately 36º 01' 28" N latitude and 84º 10' 02" W longitude. See Figure 1.4.

Site 7 – Oak Ridge City Water Treatment Plant: See Figure 1.3.

Site 8 - Scarboro Creek: Samples are taken about 500 feet upstream of Melton Hill Lake. The coordinates are approximately 35º 58' 59" N latitude and 84º 13' 00" W longitude. See Figure 1.3.

Site 9 - Kerr Hollow Branch: Samples are taken about 200 feet upstream of Melton Hill Lake. The coordinates are approximately 35º 58' 45" N latitude and 84º 13' 37" W longitude. See Figure 1.3.

Site 10 - McCoy Branch: Samples are taken underneath the power lines just upstream from Melton Hill Lake. The coordinates are approximately 35º 57' 57" N latitude and 84º 14' 54" W longitude. See Figure 1.3.

Site 11 - Western Branch: Samples are taken about 500 feet upstream of Melton Hill Lake. The coordinates are approximately 35º 58' 00" N latitude and 84º 15' 05" W longitude. See Figure 1.3.

Site 12 - East Fork of Walker Branch: Samples are taken about 300 feet upstream of Melton Hill Lake. The coordinates are approximately 35º 57' 22" N latitude and 84º 15' 58" W longitude. See Figure 1.3.

Site 13 - Bearden Creek: Samples are taken about 300 feet upstream of Melton Hill Lake. The coordinates are approximately 35º 56' 05" N latitude and 84º 17' 01" W longitude. See Figure 1.3.

Site 14 – Unnamed Stream: Samples are taken about 100 feet upstream of the Clinch River. The coordinates are approximately 35º 54' 25" N latitude and 84º 16' 39" W longitude. See Figure 1.3.

Site 15 – Unnamed Stream: Samples are taken about 75 feet upstream of the Clinch River. The coordinates are approximately 35º 54' 21" N latitude and 84º 17' 06" W longitude. See Figure 1.3.

Site 16 – Unnamed Stream: Samples are taken about 100 feet upstream of the Clinch River. The coordinates are approximately 35º 53' 22" N latitude and 84º 18' 04" W longitude. See Figure 1.2.

Site 17 – Unnamed Stream: Samples are taken about 2000 feet upstream of the Clinch River. The coordinates are approximately 35º 54' 14" N latitude and 84º 20' 12" W longitude. See Figure 1.2.

Site 18 - Raccoon Creek: Samples are taken about 1500 feet from the confluence with the Clinch River. The coordinates are approximately 35º 54' 12" N latitude and 84º 21' 05" W longitude. See Figure 1.2.

Site 19 - Ish Creek: Samples are taken about 1500 feet upstream of the Clinch River. The coordinates are approximately 35º 54' 11" N latitude and 84º 21'33" W longitude. See Figure 1.2.

Site 20 - Grassy Creek: Samples are taken about 200 feet from the confluence with the Clinch River/Grassy Creek Embayment. The coordinates are approximately 35º 54' 36" N latitude and 84º 22' 55" W longitude. See Figure 1.2.

Site 21 – Unnamed Stream: Samples are taken about 75 feet from the confluence with the Clinch River/Grassy Creek Embayment. The coordinates are approximately 35º 54' 36" N latitude and 84º 22' 57" W longitude. See Figure 1.2.

Site 22 – Unnamed Stream: Samples are taken approximately 100 feet from the confluence with the Clinch River. The coordinates are approximately 35º 54' 29" N latitude and 84º 23' 25" W longitude. See Figure 1.2.

Site 23 – Ernie's Creek: This stream is located behind Warehouse Road in Oak Ridge. Samples are taken a short distance upstream of the Clinch River embayment at Clinch River Mile 51.1. The approximate coordinates are 36º 02' 19" N latitude and 84º 12' 47" W longitude. See Figure 1.4.

Site 24 – White Creek: This stream is located in the Chuck Swann Wildlife Management Area in Union County. Samples are taken about one mile upstream of Norris Lake/Clinch River. The approximate coordinates are 36º 20' 47" N latitude and 83º 53' 42" W longitude. See Figure 1.6.

Site 25 – Clear Creek: This stream is located near Norris Dam near Clinch River Mile 77.7 Samples are taken near a water storage facility about one mile upstream of the river. The approximate coordinates are 36º 12' 49" N latitude and 84º 03' 33" W longitude. This is a background site. See Figure 1.5.

Site 32 – Clinch River Mile 19.7 (below Jones Island): The coordinates are approximately 35º 54' 03" N latitude and -84º 21' 02" W longitude. See Figure 1.2.

Site 33 – Poplar Creek Mile 0.5: The coordinates are approximately 36º 01' 03" N latitude and -84º 14' 21" W longitude. See Figure 1.1.

Site 34 – Walker Branch: The coordinates are approximately 35º 57' 10" N latitude and -84º 16' 25" W longitude. See Figure 1.3.

Site 35 – Unnamed Stream: The coordinates are approximately 35º 54' 04" N latitude and -84º 21' 59" W longitude. See Figure 1.2.

Figure 1.1: Monitoring Sites

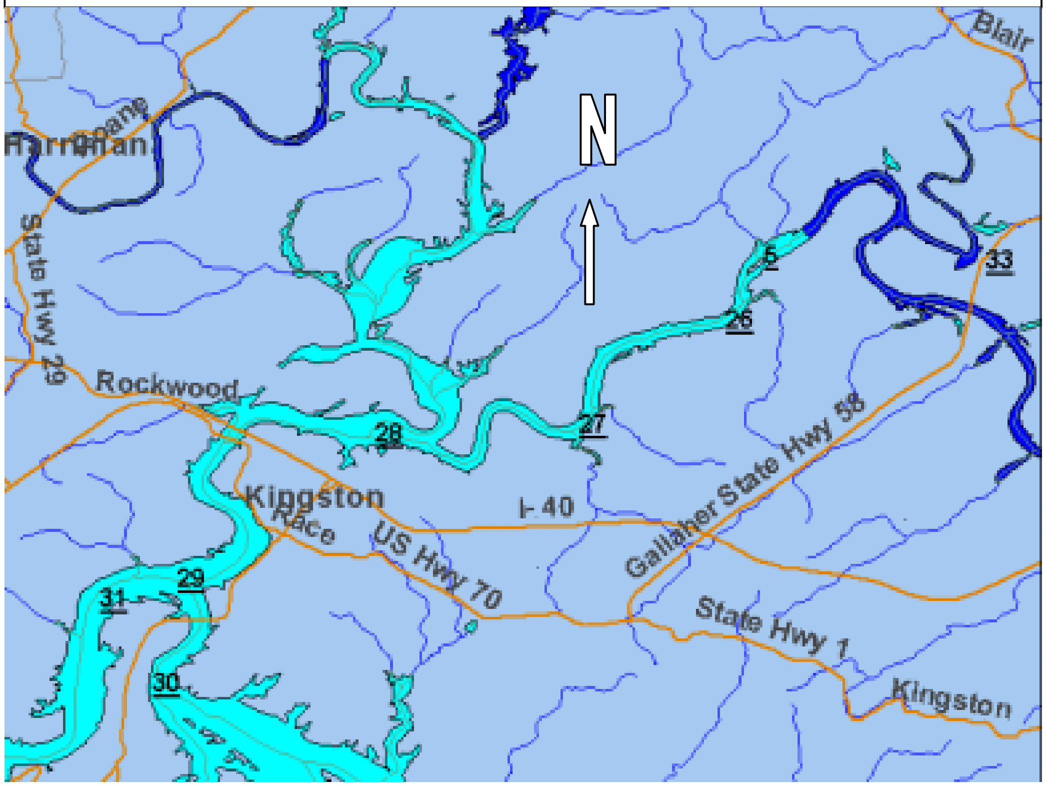


Figure1.2: Monitoring Sites

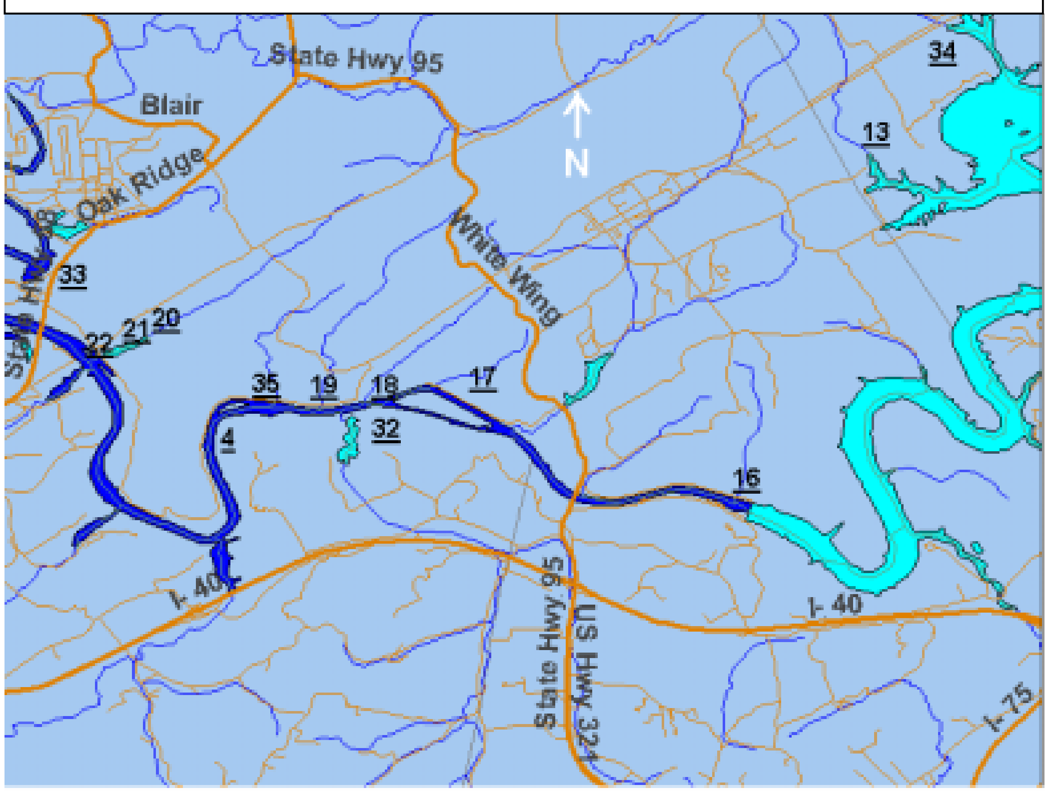


Figure 1.3: Monitoring Sites

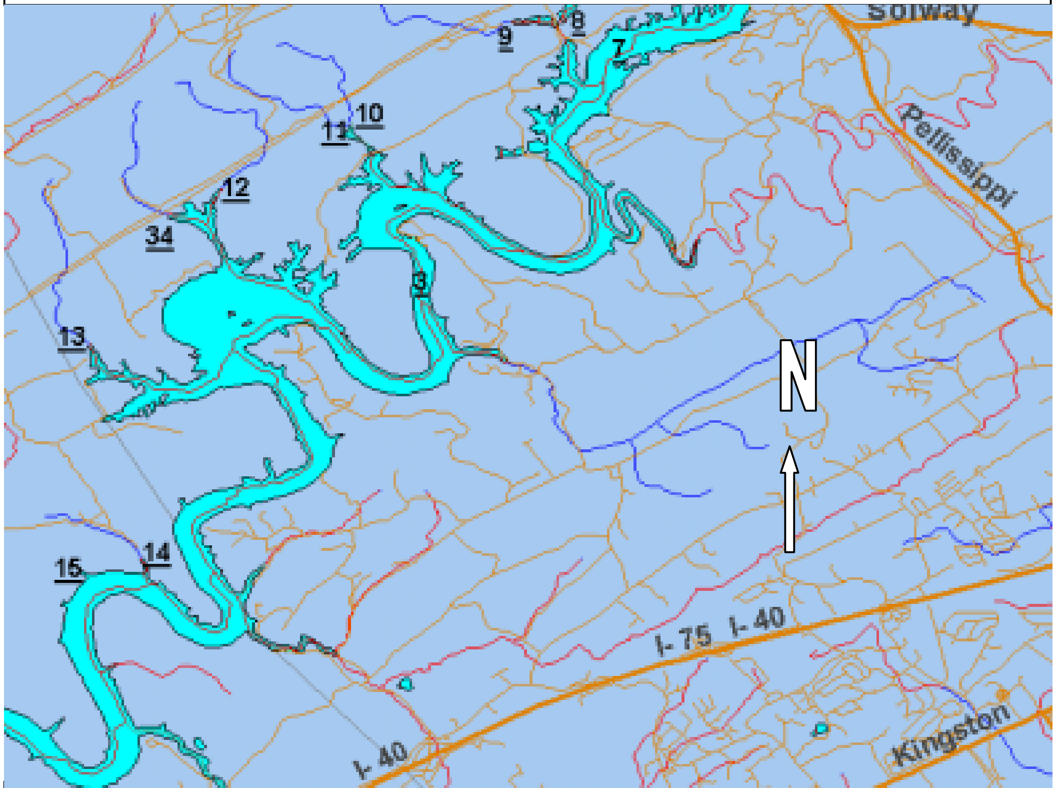


Figure 1.4: Monitoring Sites

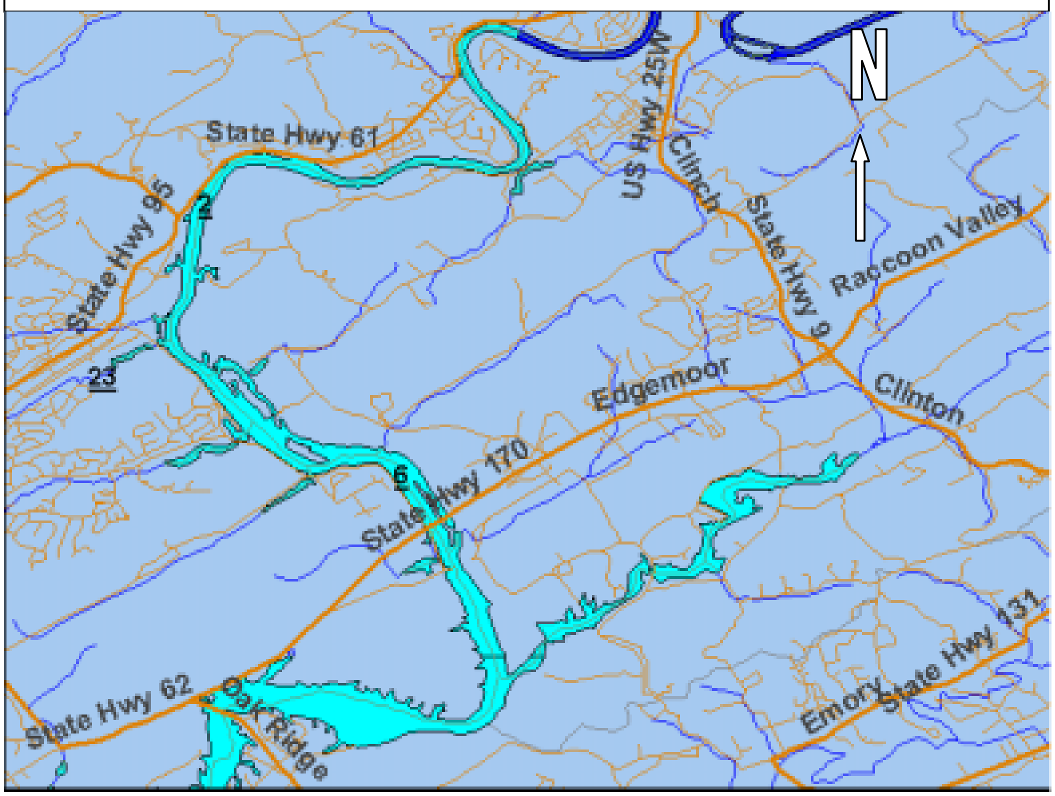


Figure 1.5: Monitoring Sites

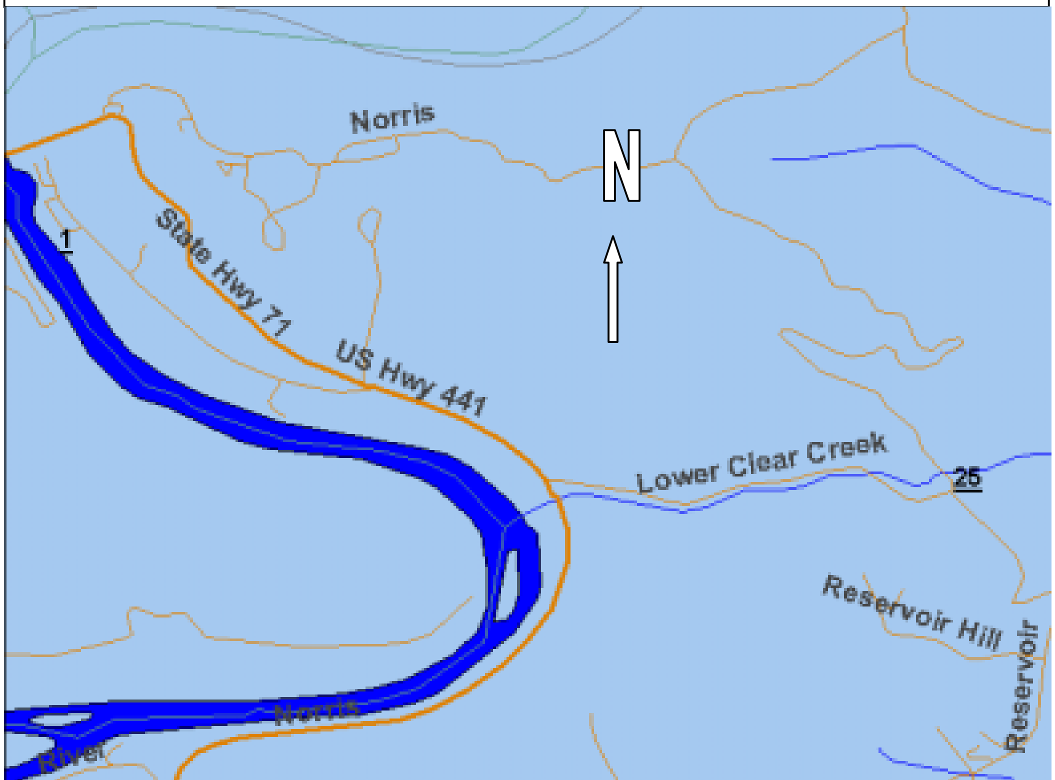
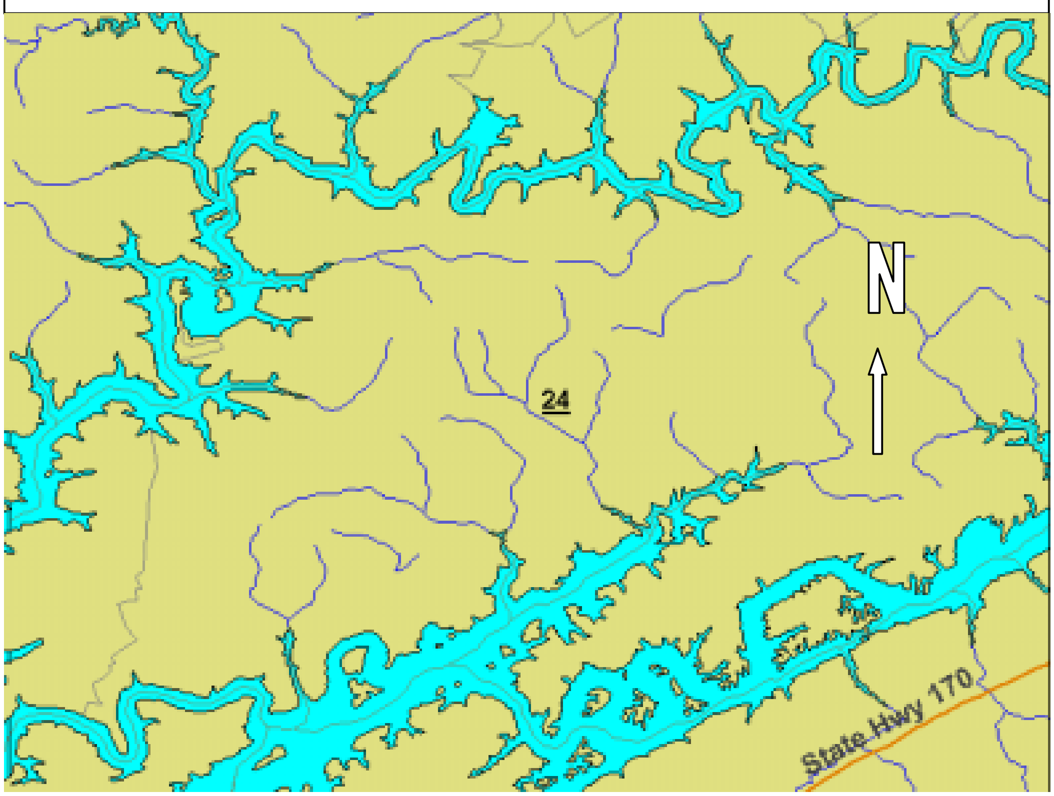


Figure 1.6: Monitoring Sites



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